
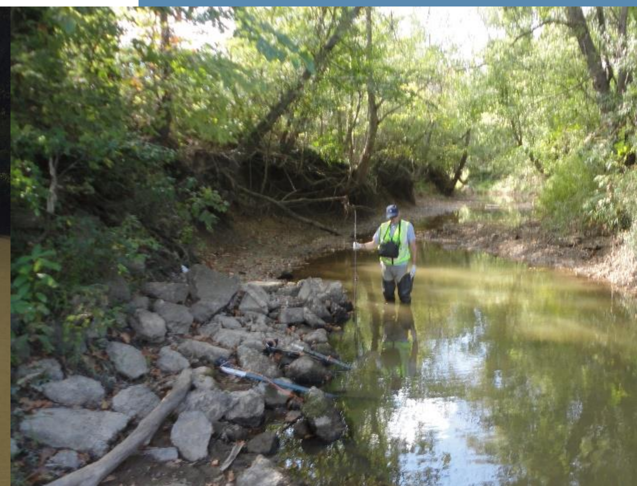
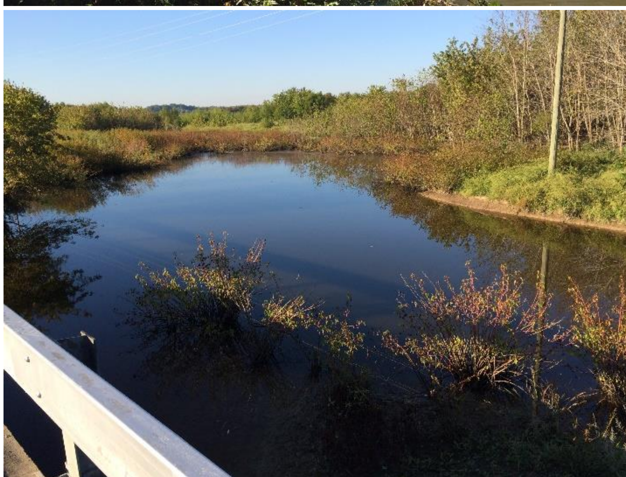


Stage 3 TMDL Report

Upper Big Muddy Watershed

Prepared for:
Illinois EPA

DRAFT for Public Comment
October 15, 2018

LimnoTech
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Upper Big Muddy River Watershed Total Maximum Daily Load

Stage 3 Report

Prepared for:
Illinois EPA

Draft for Public Comment
October 15, 2018

Prepared by:
LimnoTech

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Executive Summary

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is called the 303(d) list. The State of Illinois 303(d) lists are published every two years and are available at: http://www.epa.state.il.us/water/tmdl/303d-list.html. This report focuses on assessments based on the 2012 303(d) list (IEPA, 2012), which was the version that was final at the start of this project. Section 303(d) of the Clean Water Act and USEPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

Load Reduction Strategies (LRSs) are being completed for causes that do not have numeric standards. LRSs for causes of impairment with target criteria will consist of loading capacity and the percent reduction needed to meet the target criteria.

The following waterbodies in the Upper Big Muddy River watershed are listed on the 2012 Illinois Section 303(d) List of Impaired Waters (IEPA, 2012) as not meeting their designated uses. IEPA conducted additional sampling in 2015 on 6 of the waterbodies to support the modeling presented in this report. This document presents TMDLs for the following segments and reservoirs to allow these waterbodies to fully support their designated uses:

- Upper Big Muddy River (IL_N-11)
- Andy Cr. (IL_NZN-13)
- Lake Cr. (IL_NGA-02)
- Beaver Cr. (IL_NGAZ-JC-D1)
- Middle Fork Big Muddy (IL_NH-06)
- Arrowhead (Williamson) Lake (IL_RNZX)
- Herrin Old Reservoir (IL_RNZD)
- Johnston City Lake (IL_RNZE)
- West Frankfort Old Lake (IL_RNP)
- West Frankfort New Lake (IL_RNQ)

LRSs for the following water bodies are also presented:

- Upper Big Muddy River (IL_N-06, IL_N-11, IL_N-17)
- Pond Cr. (IL_NG-02)
- Middle Fork Big Muddy (IL_NH-07)

This report covers each step of the TMDL process and is organized as follows:

- Problem Identification

- Stage 2 Sampling
- Development of Numeric Targets
- Development of Water Quality Models
- TMDL Development
- LRS Development
- Public Participation and Involvement
- Adaptive Implementation Process
- Clean Water Act Section 319

Illinois EPA conducts TMDLs following a three-stage process. Stage 1 includes watershed characterization, data analysis and model selection. Stage 2 involves data collection, and is conducted if necessary. Stage 3 includes model calibration and application, and TMDL and implementation plan development. Upper Big Muddy River Watershed Stage 1 work began in September, 2013. A public meeting to present the Stage 1 findings and the draft Stage 1 report was held in December 2013. The final Stage 1 report was completed in January, 2014, and recommended additional monitoring for dissolved oxygen modeling, and the delisting of the following stream segments for the noted impairments:

- Andy Cr. / IL_NZN-13 – Manganese
- Hurricane Creek / IL_NF-01 – Lindane
- M. Fk. Big Muddy / IL_NH-06 – Manganese
- M. Fk. Big Muddy / IL_NH-07 – Manganese
- Prairie Cr. / IL_NZM-01 – Sulfates

Stage 2 low flow sampling was conducted in 2015 to support dissolved oxygen modeling on several stream segments in the Upper Big Muddy River watershed. As a result of this sampling and data analysis, the following stream segments are recommended for delisting based on either the waters meeting the water quality standards during the sampling period, or the low dissolved ozygen conditions were flow related:

- Big Muddy R. / IL_N-17 - Dissolved Oxygen (Sampling met WQS)
- M. Fk. Big Muddy / IL_NH-06 - Dissolved Oxygen (Low DO is due to high sediment oxygen demand / low flow)
- M. Fk. Big Muddy / IL_NH-07 - Dissolved Oxygen (Low DO is due to high sediment oxygen demand / low flow)
- Pond Cr. / IL_NG-02 - Dissolved Oxygen (Sampling met WQS)

Further data analysis as a part of the Stage 3 TMDL/LRS preparation on the following segments has indicated that the listed impairment may not currently exist:

- Hurricane Creek / IL_NF-01 - Sedimentation/Siltation
- Herrin Old / IL_RNZD - Total Suspended Solids (TSS)
- Johnston City / IL_RNZE - Total Suspended Solids (TSS)
- West Frankfort Old / IL_RNP - Total Suspended Solids (TSS)
- West Frankfort New/ IL_RNQ - Total Suspended Solids (TSS)
- Lake Cr. / IL_NGA-02 - Phosphorus (Total)
- Big Muddy R. / IL_N-11 - Sulfates

The results of these data alayses will be reevaluated during the next 303(d) listing cycle to determine if these stream segments should continue to be listed as impaired.

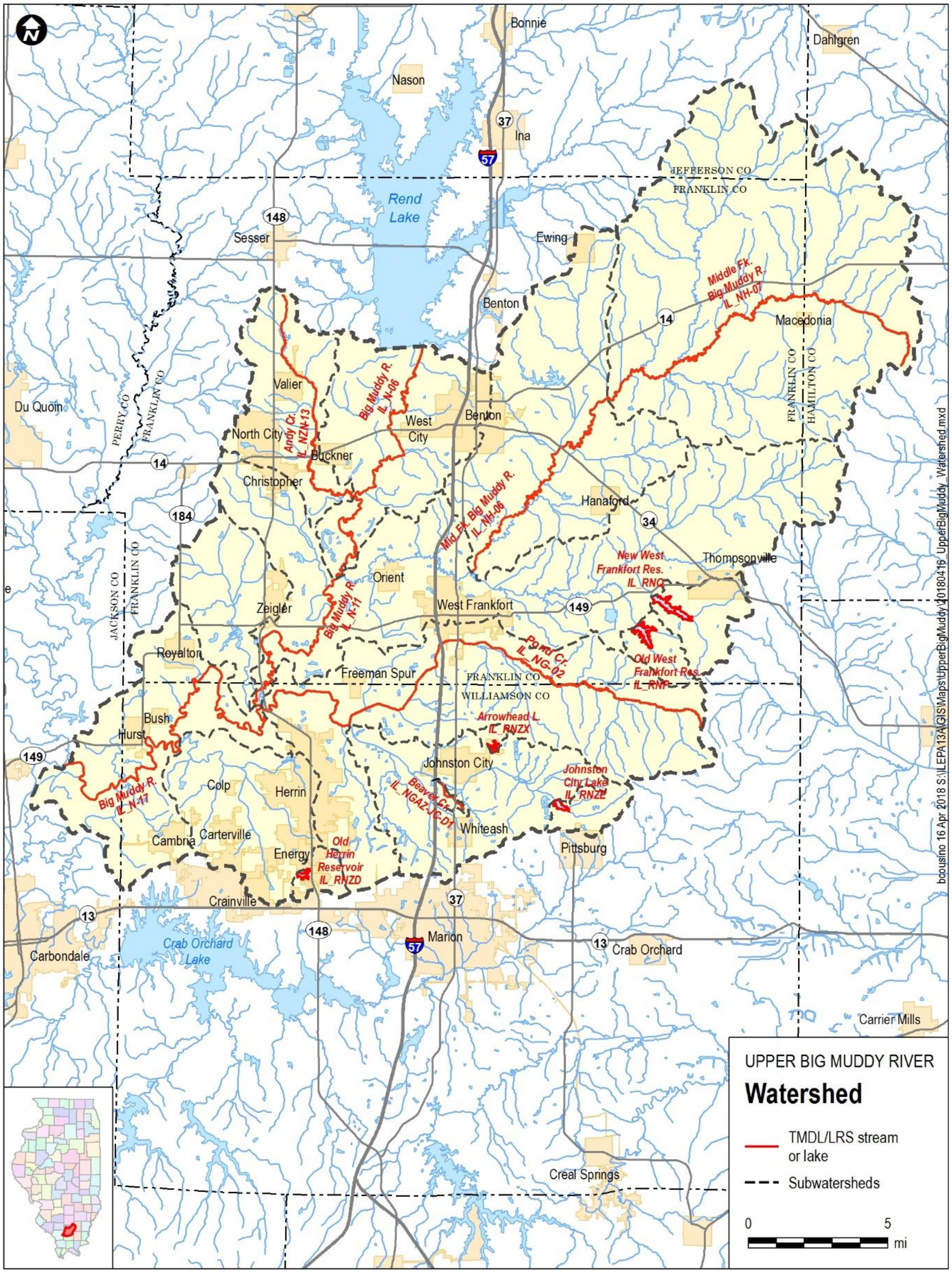

Figure 1-1. Upper Big Muddy River Watershed

1
Problem Identification

The impaired waterbodies within the Upper Big Muddy River watershed listed by the IEPA are listed below (Table 1-1), with the parameters (causes) they are listed for, and the impairment status of each designated use. The waterbodies that are proposed for delisting in the Table below are based on one of the following reasons:

1. Analysis of the data provided under Stage 1 that the existing data did not support the listed impairments.
2. Analysis of the data collected during the Stage 2 sampling performed for IEPA indicated that the impairments may not currently exist.
3. Analysis of the data collected during the Stage 2 sampling performed for IEPA indicated that the impairments are due to low flow conditions, not pollutant loading.
4. Based on a comparison of TSS data to the LRS target concentration developed by IEPA, it was determined that TSS reduction is not needed.
5. Based on a comparison of TP data to the LRS target concentration developed by IEPA, it was determined that TP reduction is not needed.

Table 1-1. Impaired Waterbody Summary

Waterbody/ Segment ID	Size (mile/ac)	Impaired Designated Use	Impairment Cause	Proposed Action
Big Muddy R. / IL_N-06	15.13 mi	Aquatic life	Sedimentation/Siltation	Prepare LRS
Big Muddy R. / IL_N-11	11.48 mi	Aquatic life	Sulfates	**Delist (1)**
		Primary contact recreation	Fecal Coliform	Prepare TMDL
		Aquatic life	Sedimentation/Siltation, TSS	Prepare LRS
Big Muddy R. / IL_N-17	21.48 mi	Aquatic life	Dissolved Oxygen	**Delist (2)**
		Aquatic life	Sedimentation/Siltation, TSS	Prepare LRS
Hurricane Creek / IL_NF-01	10.6 mi	Aquatic life	Lindane	**Delist (1)**
		Aquatic life	Sedimentation/Siltation	**Delist (4)**
Prairie Cr. / IL_NZM-01	9.06 mi	Aquatic life	Sulfates	**Delist (1)**
Andy Cr. / IL_NZN-13	11.7 mi	Aquatic life	Iron	Prepare TMDL
		Aquatic life	Manganese	Delist (1)
		Aquatic life	Dissolved Oxygen	Delist (3)
Herrin Old / IL_RNZD	51.3 ac	Aesthetic Quality	Phosphorus (Total)	Prepare TMDL
		Aesthetic Quality	Total Suspended Solids (TSS)	**Delist (4)**
Pond Cr. / IL_NG-02	23.53 mi	Aquatic life	Chloride	Delist (1)
		Aquatic life	Dissolved Oxygen	**Delist (2)**

Waterbody/ Segment ID	Size (mile/ac)	Impaired Designated Use	Impairment Cause	Proposed Action
		Aquatic life	Sedimentation/Siltation	Prepare LRS
Lake Cr. / IL_NGA-02	12.33 mi	Aquatic life	Dissolved Oxygen	Prepare TMDL
		Aquatic life	Phosphorus (Total)	**Delist (5)**
Beaver Cr. / IL_NGAZ-JC-D1	1.7 mi	Aquatic life	Manganese	Prepare TMDL
Johnston City / IL_RNZE	64 ac	Aesthetic Quality	Phosphorus (Total)	Prepare TMDL
		Aesthetic Quality	Total Suspended Solids (TSS)	**Delist (4)**
Arrowhead (Williamson) / IL_RNZX	30 ac	Aesthetic Quality	Phosphorus (Total)	Prepare TMDL
M. Fk. Big Muddy / IL_NH-06	12.52 mi	Primary contact recreation	Fecal Coliform	Prepare TMDL
		Aquatic life	Dissolved Oxygen	**Delist (3)**
		Aquatic life	Manganese	**Delist (1)**
M. Fk. Big Muddy / IL_NH-07	19.74 mi	Aquatic life	Dissolved Oxygen	**Delist (3)**
		Aquatic life	Manganese	**Delist (1)**
		Aquatic life	Sedimentation/Siltation	Prepare LRS
West Frankfort Old / IL_RNP	146 ac	Aesthetic Quality	Phosphorus (Total)	Prepare TMDL
		Aesthetic Quality	Total Suspended Solids (TSS)	**Delist (4)**
West Frankfort New/ IL_RNQ	214 ac	Aesthetic Quality	Phosphorus (Total)	Prepare TMDL
		Aesthetic Quality	Total Suspended Solids (TSS)	**Delist (4)**

Delisting of the stream segments identified in the table able will occur as a part of a future 303(d) listing process based on the reasons noted above. TMDLs are currently only being developed for pollutants that have numerical water quality standards. Load Reduction Strategies (LRSs) are being developed for pollutants that do not have numerical water quality standards. All of the waterbodies that are being addressed in this Stage 3 report and the implementation plan are summarized in Table 1-2 below.

Table 1-2. TMDL & LRS Waterbody Summary

Waterbody/ Segment ID	Size (mile/ac)	Impaired Designated Use	Impairment Cause	Proposed Action
Big Muddy R. / IL_N-06	15.13 mi	Aquatic life	Sedimentation/Siltation	Prepare LRS
Big Muddy R. / IL_N-11	11.48 mi	Primary contact recreation	Fecal Coliform	Prepare TMDL
		Aquatic life	Sedimentation/Siltation, TSS	Prepare LRS
Big Muddy R. / IL_N-17	21.48 mi	Aquatic life	Sedimentation/Siltation, TSS	Prepare LRS
Andy Cr. / IL_NZN-13	11.7 mi	Aquatic life	Iron	Prepare TMDL
		Aquatic life	Dissolved Oxygen	Prepare TMDL
Herrin Old / IL_RNZD	51.3 ac	Aesthetic Quality	Phosphorus (Total)	Prepare TMDL
Pond Cr. / IL_NG-02	23.53 mi	Aquatic life	Chloride	Prepare TMDL
		Aquatic life	Sedimentation/Siltation	Prepare LRS

Waterbody/ Segment ID	Size (mile/ac)	Impaired Designated Use	Impairment Cause	Proposed Action
Lake Cr. / IL_NGA-02	12.33 mi	Aquatic life	Dissolved Oxygen	Prepare TMDL
Beaver Cr. / IL_NGAZ-JC-D1	1.7 mi	Aquatic life	Manganese	Prepare TMDL
Johnston City / IL_RNZE	64 ac	Aesthetic Quality	Phosphorus (Total)	Prepare TMDL
Arrowhead (Williamson) / IL_RNZX	30 ac	Aesthetic Quality	Phosphorus (Total)	Prepare TMDL
M. Fk. Big Muddy / IL_NH-06	12.52 mi	Primary contact recreation	Fecal Coliform	Prepare TMDL
M. Fk. Big Muddy / IL_NH-07	19.74 mi	Aquatic life	Sedimentation/Siltation	Prepare LRS
West Frankfort Old / IL_RNP	146 ac	Aesthetic Quality	Phosphorus (Total)	Prepare TMDL
West Frankfort New/ IL_RNQ	214 ac	Aesthetic Quality	Phosphorus (Total)	Prepare TMDL

2
Stage 2 Sampling

The Stage 1 report recommended additional sampling be conducted during low flow conditions to support dissolved oxygen modeling in support of TMDL development. In 2015, IEPA conducted Stage 2 sampling to support dissolved oxygen TMDL modeling. Samples were collected in September and October of 2015, and data were reported for CBOD5, BOD5, Nitrite-Nitrate Nitrogen, Ammonia, total kjeldahl nitrogen (TKN), total phosphorus, dissolved phosphorus, chlorophyll a, total suspended solids and volatile suspended solids, and sediment oxygen demand (SOD). Flow, velocity and channel morphometry were also recorded during sampling.

Figure 2-1 shows the locations sampled in 2015. The data collected at these locations were used in the dissolved oxygen modeling described in this report. TMDLs and LRSs for other parameters were based on existing data, previously collected by IEPA and described in the Stage 1 report (Attachment 1).

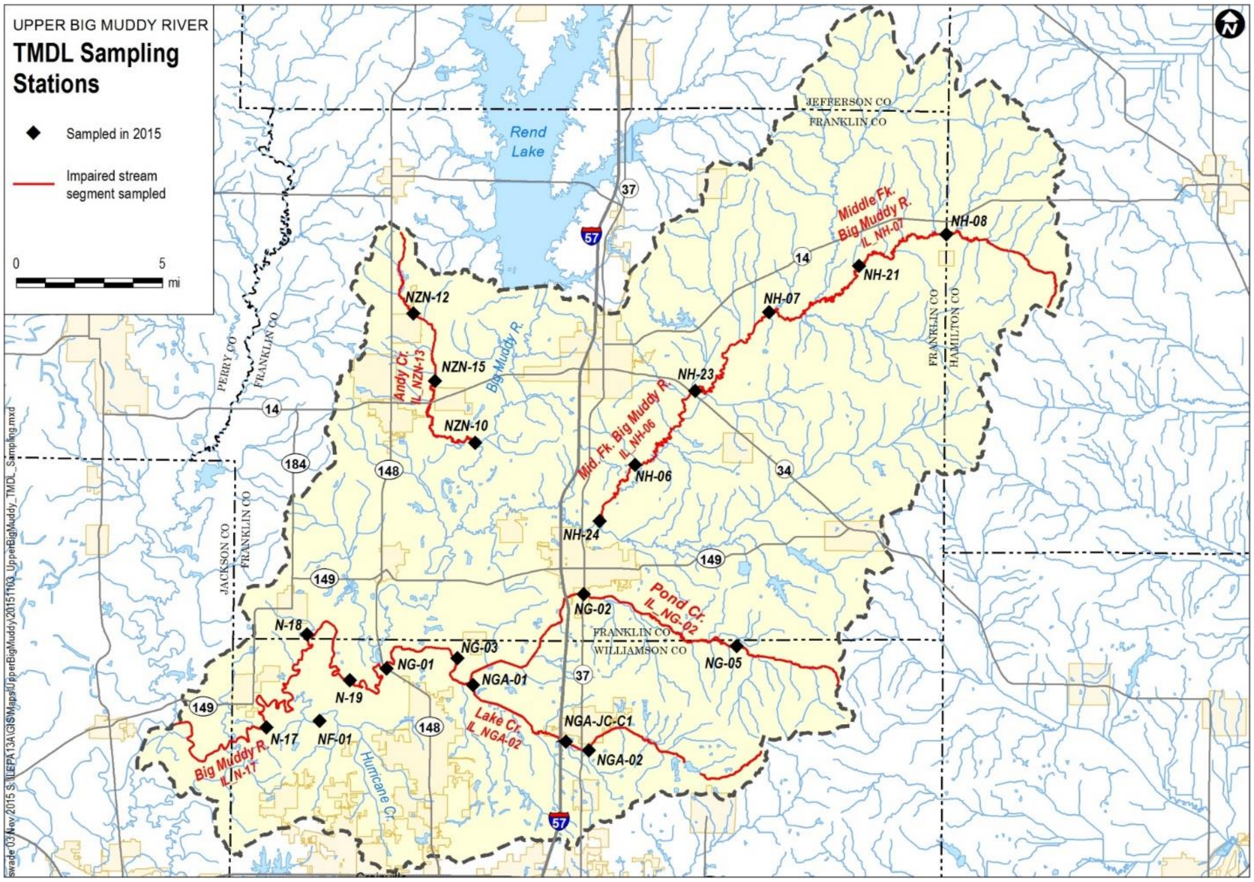

Figure 2-1. 2015 Sampling Locations in the Upper Big Muddy River Watershed

3 Development of Numeric Targets

Designated use, use support and water quality criteria for waterbodies in the Upper Big Muddy River watershed have been previously described in the Stage 1 Report (Attachment 1). This section describes the development of numeric TMDL and LRS targets.

3.1 Development of TMDL and LRS Targets

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint.

3.1.1 Phosphorus (Total)

The General Use standards for phosphorus are in Section 302.205 of Title 35. For the phosphorus TMDLs in the lakes within the Upper Big Muddy River watershed, the target is set at the water quality criterion for total phosphorus of 0.05 mg/L.

When appropriate numeric standards do not exist, surrogate parameters must be selected to represent protection of the designated use. For streams and rivers in the Upper Big Muddy River watershed, IEPA has developed a total phosphorus LRS target of 0.217 mg/L (IEPA, 2016). This target is based on an average of validated, real-world data (1999-2013) for the nearby Upper Kaskaskia watershed, which contains several streams that are in full support of aquatic life. This LRS target was ultimately not used to develop a total phosphorus LRS because the average phosphorus concentrations measured in the stream segments listed for TP impairment were below this LRS target concentration.

3.1.2 Dissolved Oxygen

The General Use standards for dissolved oxygen are in Section 302.206 of Title 35. For the Upper Big Muddy River watershed dissolved oxygen TMDLs in streams, the target is set at the water quality criterion for daily minimum dissolved oxygen of 5.0 mg/L recognizing that this is the more conservative of the seasonal minimal dissolved oxygen criteria (recall that between August and February, the minimum is 3.5 mg/L). The QUAL2E models used to calculate the TMDLs predicts a daily average dissolved oxygen concentration and does not directly predict daily minimum values. QUAL2E results can be translated into a form comparable to a daily minimum, by subtracting the observed difference between daily average and daily minimum dissolved oxygen from the model output.

3.1.3 Iron

The General Use standards for iron are in Section 302.208 of Title 35. A single-value standard of 1.0 mg/L applies to dissolved iron, and this is the target used for TMDL development for the Andy Creek (IL_NZN-13) segment.

3.1.4 Manganese

The General Use standards for manganese are in Section 302.208 of Title 35. The water quality standards for dissolved manganese are given by the following equations:

Acute Standard:

$WQS = e^{A+Bln(H)} \times 0.9812$

where A = 4.9187 and B = 0.7467;

and ln(H) is the natural logarithm of the hardness in mg/L.

<u>*Chronic Standard:*</u>

$WQS = e^{A+Bln(H)} \times 0.9812$

where A = 4.0635 and B = 0.7467;

and ln(H) is the natural logarithm of the hardness in mg/L.

The chronic standard was used to develop the manganese TMDL for Beaver Cr. (IL_NGAZ-JC-D) in the Upper Big Muddy River watershed. The calculated target for this stream segment is shown in section 4.2.6.

3.1.5 Fecal Coliform

The General Use standards for fecal coliform bacteria are in Section 302.209 of Title 35. During the months May through October (swimming-season), based on a minimum of five samples taken over not more than a 30 day period, fecal coliform bacteria shall not exceed a geometric mean of 200 per 100 mL, nor shall more than 10% of the samples during any 30 day period exceed 400 per 100 mL. For fecal coliform TMDLs in the Upper Big Muddy River watershed, the target is conservatively set at the water quality criterion of 200 colony forming units (cfu)/100 mL.

3.1.6 Total Suspended Solids (TSS)

When appropriate numeric standards do not exist, surrogate parameters must be selected to represent protection of the designated use. For all streams and rivers in the Upper Big Muddy River watershed, IEPA has developed a LRS target of 32.2 mg/L TSS (IEPA, 2016). This target is based on an average of validated, real-world data (1999-2013) for the nearby Upper Kaskaskia watershed, which contains several streams that are in full support of aquatic life.

Based on an average of validated, real-world data for these streams over a period from 1999 to 2013, the load reduction targets for all streams in this watershed are as follows:

- Total Suspended Solids: 32.2 milligrams/liter

For all lakes in the watershed, the load reduction targets are as follows:

- Total Suspended Solids: 23 milligrams/liter

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4
Development of Water Quality Models

Water quality models are used to define the relationship between pollutant loading and the resulting water quality. This section describes the modeling to support TMDL and LRS development, and is divided into the following sections:

- QUAL2E modeling for dissolved oxygen TMDL
- Load Duration Curve approach for fecal coliform, sulfate, iron, manganese, and chloride TMDLs
- BATHTUB modeling for total phosphorus TMDLs for reservoirs.

The remainder of this section describes the TSS modeling to support the TSS LRS.

4.1 QUAL2E Model for the Dissolved Oxygen TMDLs

The QUAL2E water quality model was used to define the relationship between external oxygen-demanding loads and the resulting concentrations of dissolved oxygen in the Lake Cr. (IL_NGA-02) stream segment in the Upper Big Muddy River watershed.

In addition, QUAL2E to was used to model the the dissolved oxygen in Pond Creek (IL_) and Andy Creek (IL_NZN-) to determine if the observed low dissolved oxygen was based on pollutant loads, or low flow conditions. Based on the results of those models, no TMDLs were developed for those stream segments.

QUAL2E is a one-dimensional stream water quality model applicable to dendritic, well-mixed streams. It assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the main direction of flow. The model allows for multiple waste discharges, water withdrawals, tributary flows, and incremental inflows and outflows.

4.1.1 Model Selection

A discussion of the model selection process for the Upper Big Muddy River watershed is provided in the Stage 1 report (Attachment 1).

The QUAL2E model (Brown and Barnwell, 1987) was selected to address dissolved oxygen impairments in the Upper Big Muddy River watershed. QUAL2E is the most commonly used water quality model for addressing low flow conditions.

4.1.2 Modeling Approach

The approach selected for the dissolved oxygen TMDL consists of using data collected during 2015 low flow season surveys to define the current water quality of the river, and using the QUAL2E model to define the extent to which loads must be reduced to meet water quality standards. This is the recommended approach presented in the Stage 1 report.

4.1.3 QUAL2E Model Inputs

This section gives an overview of the model inputs required for QUAL2E application, and how they were derived. The following categories of inputs are required for QUAL2E:

- Model options (title data)
- Model segmentation

- Hydraulic characteristics
- Reach kinetic coefficients
- Initial conditions
- Incremental inflow conditions
- Headwater characteristics
- Point source flows and loads

4.1.3.a Model Options

This portion of the model input parameters defines the specific water quality constituents to be simulated. QUAL2E was set up to simulate temperature, biochemical oxygen demand, the nitrogen series, phosphorus, algae and dissolved oxygen.

4.1.4 Andy Cr. (IL_NZN-13) QUAL2E Model Application

This sections described the application of the QUAL2E model to the above noted stream segment.

4.1.4.a Model Segmentation

The QUAL2E model divides the river being simulated into discrete segments (called "reaches") that are considered to have constant channel geometry and hydraulic characteristics. Reaches are further divided into "computational elements", which define the interval at which results are provided. Andy Creek QUAL2E model consists of two reaches, which are comprised of a varying number of computational elements. Computational elements were specified to have a fixed length of 0.20 miles. Reaches are defined with respect to water quality monitoring stations and tributaries. Model segmentation is presented below in Table 4-1 and Figure 4-1.

Table 4-1. Andy Creek QUAL2E Segmentation

Reach	River miles	Number of computational elements	Other features
1	8.25 – 5.0	13	NZN-12, Valier STP, NZN-15
2	5.0 – 0.0	20	NZN-10

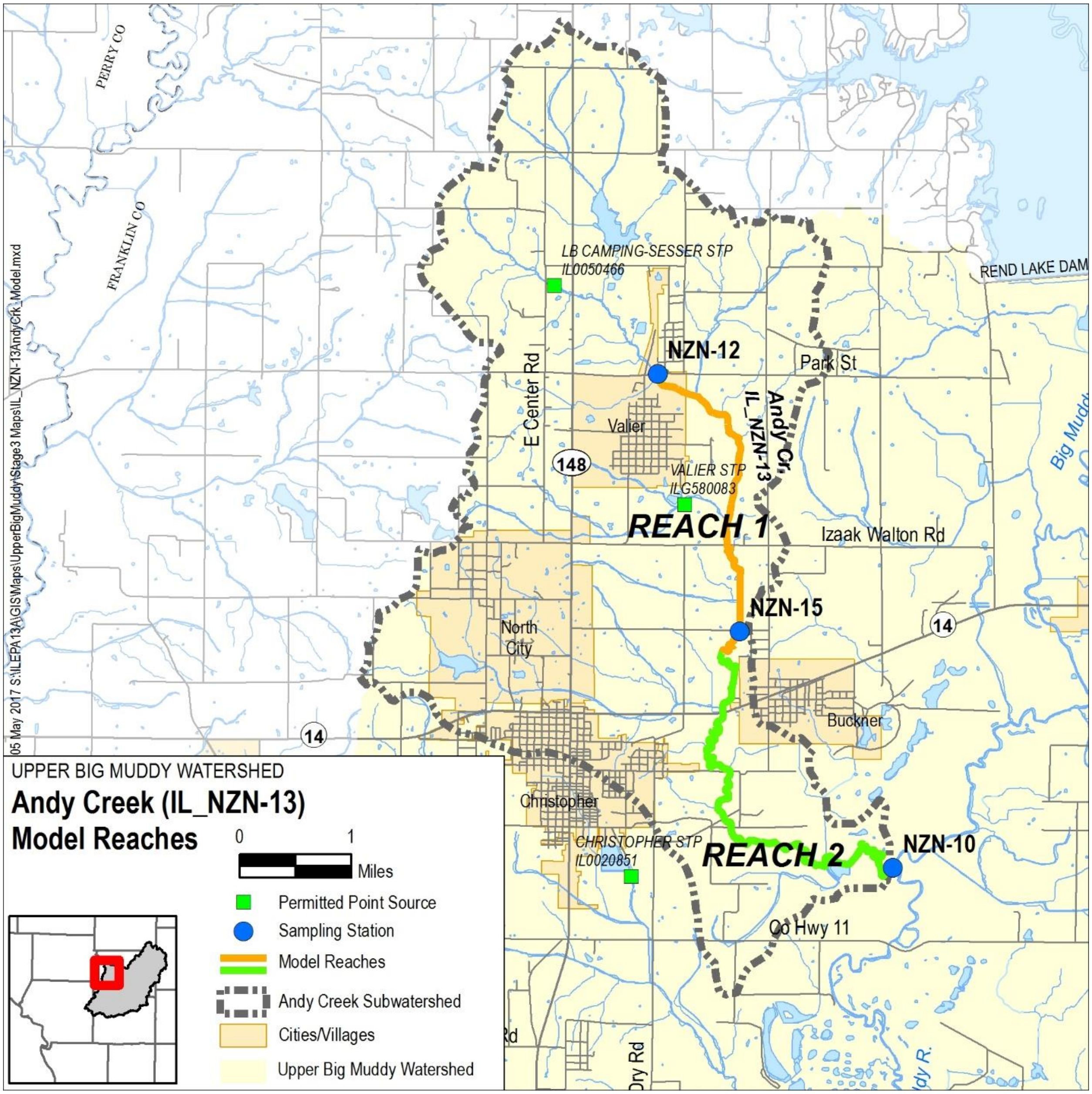

Figure 4-1. Andy Creek QUAL2E Segmentation

4.1.4.b Hydraulic characteristics

A functional representation was used to describe the hydraulic characteristics of the system. For each reach, velocity and depth were specified, based on measurements taken during the September 23, 2015 field survey.

4.1.4.c Reach Kinetic Coefficients

Kinetic coefficients were initially set at values commonly used in past QUAL2E applications from Illinois. The appropriateness of these initial values were assessed during the model calibration process, where these coefficients were refined as necessary (within accepted ranges taken from the scientific literature) to allow model results to best describe observed water quality data.

4.1.4.d Initial Conditions

Initial model conditions were based on field observations, flow measurements, and water quality data collected during 2015. Specifically, observed concentrations of ammonia, phosphorus, organic nitrogen, nitrate and chlorophyll a were used to specify initial conditions.

4.1.4.e Incremental Inflow Conditions

Incremental inflows were calculated using a drainage area ratio and field measured flows. Increases in flows were added to each reach incrementally to represent non-monitored tributaries (flows were increasing from upstream to downstream). Concentrations for these incremental inflows were considered to have concentrations at typical background levels, and temperatures consistent with the mainstem. Other flows came from the headwater and point sources.

4.1.4.f Headwater Characteristics

Headwater characteristics were based on the flow/water quality measurements collected at the more upstream IEPA station (NZN-12).

4.1.4.g Point Source Flows and Loads

There are two permitted NPDES discharges from sewage treatment plants in the Andy Creek watershed. The NPDES permits are for the LB Camping Sesser STP (IL0050466) and the Valier STP (ILG580083). (Attachment 1, Section 2.9).

The model considers one permitted point source that discharges to Andy Creek via a small tributary. The upsrtream point source (LB Camping Sesser STP) is assumed to contribute no load or small loads (based on discharge monitoring report (DMR) data and some assumptions where data was not available), and any impacts on the DO impairments to Andy Creek at the downstream stations would be incorporated into the model by using the sampling data collected at station NZN-12 as the upstream boundary conditions. See Table 4-2 for details of when data were used, and when assumptions were made.

Table 4-2. Andy Creek (IL_NZN-13) Concentrations of QUAL2E model inputs

Model input point	Flow (cfs)	Temp. (Deg F)	DO (mg/L)	CBOD5 (mg/L)	Ammonia (mg/L)	Source
Headwater	0.10	63.7	4.47	1	0.05	Data collected at NZN-12
Valier STP discharge to Reach 1	0.06	70	8.70	10.90	5.80	DMR data (flow, CBOD5, DO, Ammonia)
Incremental inflow to Reach 1	0.145	65.0	4.5	1	0.00	Calculated from flow balance. Water quality specified based on typical background levels.

4.1.4.h QUAL2E Model Calibration

QUAL2E model calibration consisted of:

- Applying the model with all inputs specified as above
- Comparing model results to observed dissolved oxygen, BOD, ammonia, and chlorophyll data
- Adjusting model coefficients to provide the best comparison between model predictions and observed dissolved oxygen data.

The QUAL2E dissolved oxygen calibration for Andy Creek is discussed below. The model was initially applied with the model inputs as specified above. Observed data for the low flow survey conducted on September 23, 2015 was used for calibration purposes.

QUAL2E was calibrated to match the observed average dissolved oxygen concentrations measured at two locations (NZN-15 and NZN-10) on the mainstem of the creek. The data collected at NZN-12 was used to define the upstream boundary conditions. The initial BOD calibration was deemed successful, albeit not totally conclusive, as the majority of observed data (as well as model predictions) for both parameters were below laboratory detection limits. Similarly, the initial coefficients used to describe chlorophyll a correctly replicated observed low observed field concentrations and confirmed that algal productivity was not an important component of the dissolved oxygen budget.

Model results initially over-predicted observed dissolved oxygen data. Model calibration was attained by adjusting reach-specific sediment oxygen demand, with calibration values ranging from 0.054 to 0.065 mg/sq. ft./day. Those values were initially based on the SOD measurement taken at NZN-15 of 0.065 mg/sq. ft./day. The resulting dissolved oxygen predictions compared well to the measured concentrations as shown in Figure 4-2. The QUAL2E model output files from the calibration runs are included in Attachment 3.

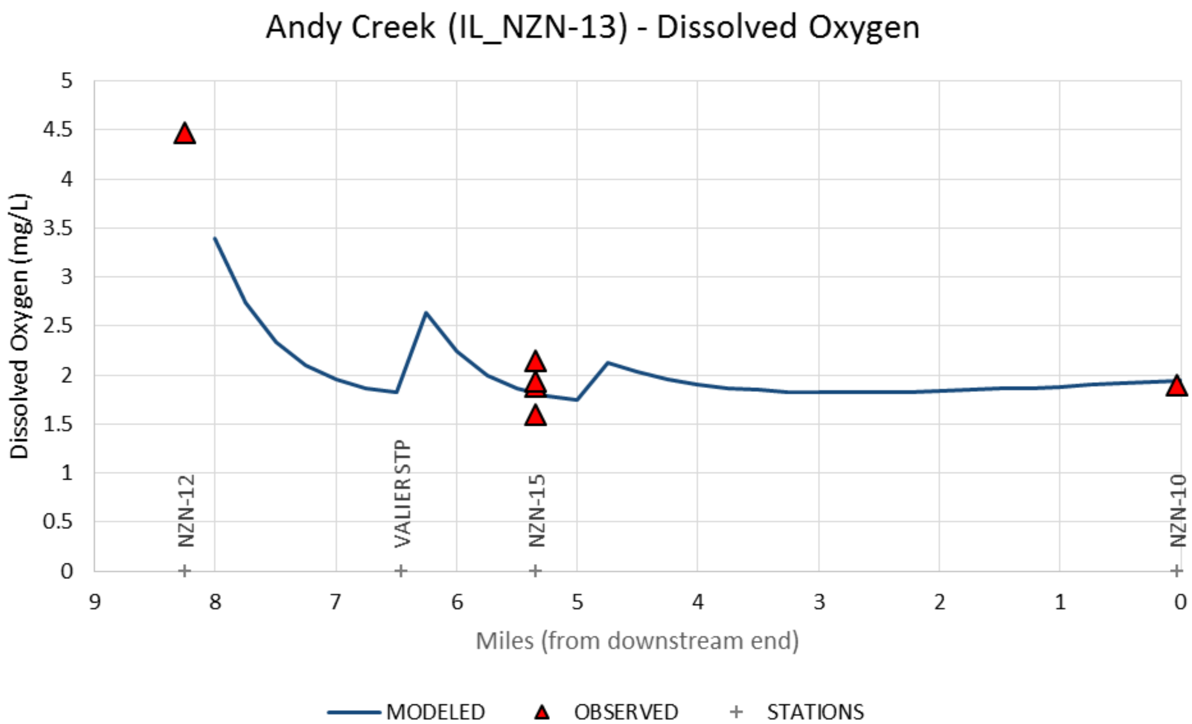

Figure 4-2. QUAL2E DO Calibration for Andy Creek for 9/23/2015 Sampling Survey

4.1.5 Lake Cr. (IL_NGA-02) QUAL2E Model Application

This sections described the application of the QUAL2E model to the above noted stream segment.

4.1.5.a Model Segmentation

The QUAL2E model divides the river being simulated into discrete segments (called “reaches”) that are considered to have constant channel geometry and hydraulic characteristics. Reaches are further divided into “computational elements”, which define the interval at which results are provided. The Lake Creek QUAL2E model consists of two reaches, which are comprised of a varying number of computational elements. Computational elements were specified to have a fixed length of 0.25 miles. Reaches are defined with respect to water quality monitoring stations and tributaries. Model segmentation is presented below in Table 4-3 and Figure 4-3. The division between reaches 1 and 2 was determined based on the location of additional tributaries that contribute additional flow to the stream which would be expected to change the hydraulic characteristics of the reach.

Table 4-3. Lake Creek QUAL2E Segmentation

Reach	River miles	Number of computational elements	Other features
1	3.25 – 5.25	8	NGA-02, Johnston City STP, NGA-JC-C1
2	0 – 3.25	14	NGA-01

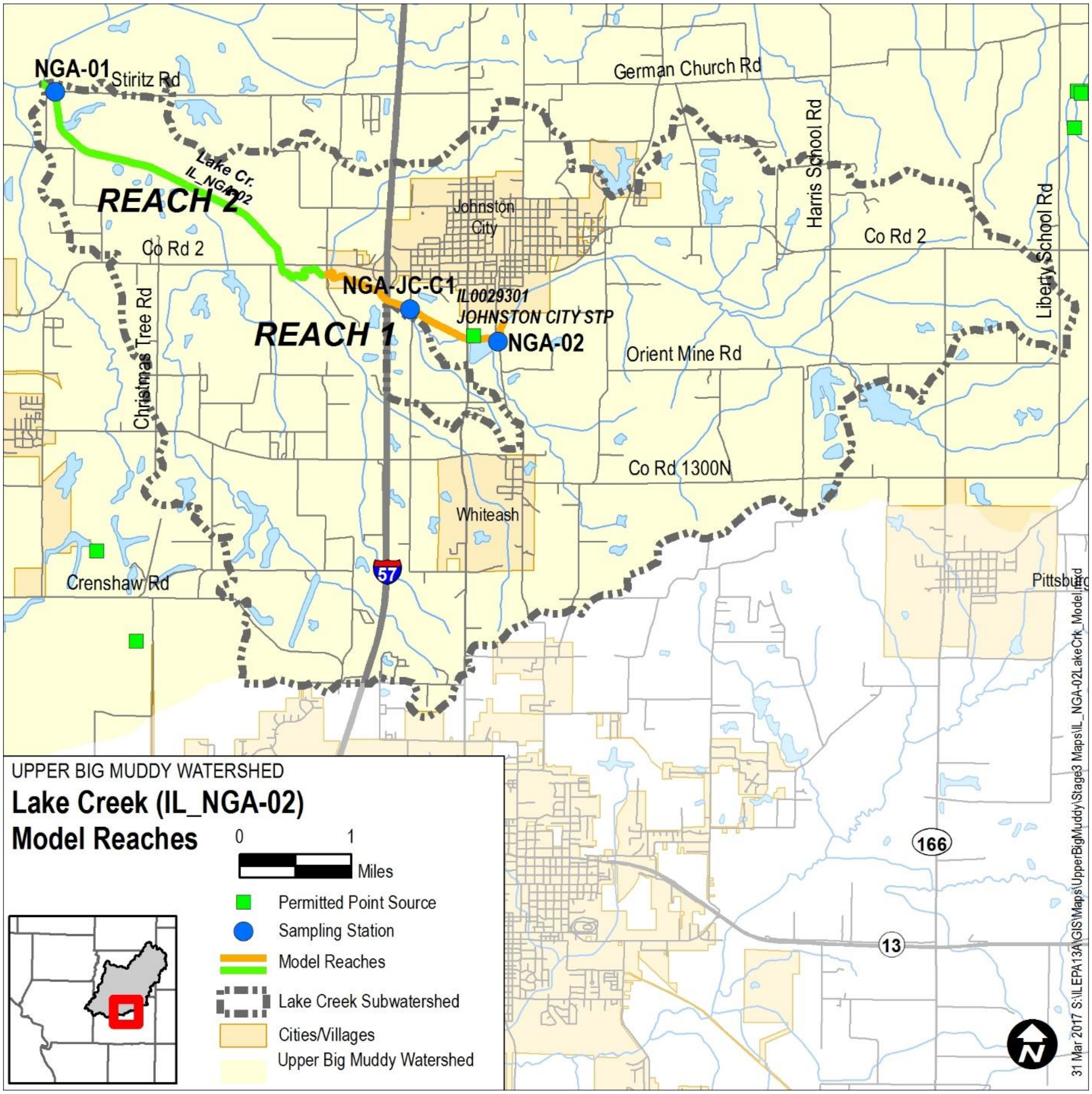

Figure 4-3. Lake Creek (IL_NGA-02) QUAL2E Model Segmentation

4.1.5.b Hydraulic characteristics

A functional representation was used to describe the hydraulic characteristics of the system. For each reach, velocity and depth were specified, based on measurements taken during the August, September and October 2015 field surveys.

4.1.5.c Reach Kinetic Coefficients

Kinetic coefficients were initially set at values commonly used in past QUAL2E applications from Illinois. The appropriateness of these initial values were assessed during the model calibration process, where these coefficients were refined as necessary (within accepted ranges taken from the scientific literature) to allow model results to best describe observed water quality data.

4.1.5.d Initial Conditions

Initial model conditions were based on field observations taken during 2015 and USGS flow measurements. Specifically, observed concentrations of ammonia, phosphorus, organic nitrogen, nitrate and chlorophyll a were used to specify initial conditions.

4.1.5.e Incremental Inflow Conditions

Incremental inflows were calculated using a drainage area ratio and measured USGS flows. Increases in flows were added to each reach incrementally to represent non-monitored tributaries (flows were increasing from upstream to downstream). Concentrations for these incremental inflows were considered to have concentrations at typical background levels, and temperatures consistent with the mainstem. Other flows came from the headwater and point sources.

4.1.5.f Headwater Characteristics

Headwater characteristics were based on the flow/water quality measurements collected at the more upstream IEPA station (NGA-02).

4.1.5.g Point Source Flows and Loads

There is one permitted NPDES discharges in the Lake Creek watershed. It is for the Johnston City STP (IL0029301), a municipal sewage treatment plant. See Table 4-4 for details of when data were used, and when assumptions were made.

Table 4-4. Lake Creek (IL_NGA-02) Concentrations of QUAL2e model inputs

Model input point	Flow (cfs)	Temp. (Deg F)	DO (mg/L)	$CBOD_5$ (mg/L)	Ammonia (mg/L)	Source
Headwater	0.10	63.7	4.47	1	0.05	Data collected at NGA-02, or calculated from flow balance.
Johnston City STP discharge to Reach 1	0.75	70	7.6	14.2	8.90	DMR data (flow, CBOD5, DO), data from NGA-JC-C1 (Ammonia).
Incremental inflow to Reach 2	4.69	65.0	9.0	1	0.00	Calculated from flow balance. Water quality specified based on typical background levels.

It is noted that DMR data from the September 2015 for Johnston City STP indicate that the monthly average CBOD5 concentration (14.2 mg/l) exceeded the permit limit of 10 mg/L, along with effluent violations of daily maximum and monthly average ammonia nitrogen concentrations, although it is uncertain whether the effluent limit violations were occurring specifically during the time of the survey. The of $CBOD_5$ in the Johnston City STP were based on the September 2015 DMR for that facility. The $CBOD_5$ and DO concentrations used to characterize the point load in the QUAL2E model were the monthly averages. The daily maximum $CBOD_5$ was 17 mg/L, but there is no information on whether that occurred on the date of the sampling. The ammonia nitrogen concentration used in the model to characterize the point load was based on the observed concentration at station NGA-JC-C1, which is higher than the reported daily maximum value for ammonia nitrogen in the DMR. The effluent sampling frequency for ammonia nitrogen required in the NPDES permit for the Johnston City STP is only two days per month, so it is possible that higher concentrations could occur between samples. The flow used was the daily average flow for the month reported in the DMR of 0.488 MGD, which is lower than the design average flow for the facility of 0.55 MGD.

4.1.5.h QUAL2E Model Calibration

QUAL2E model calibration consisted of:

- Applying the model with all inputs specified as above
- Comparing model results to observed dissolved oxygen, BOD, ammonia, and chlorophyll data
- Adjusting model coefficients to provide the best comparison between model predictions and observed dissolved oxygen data.

The QUAL2E dissolved oxygen calibration for Lake Creek (IL_NGA-02) is discussed below. The model was initially applied with the model inputs as specified above. Observed data for the low flow survey conducted in 2015 was used for calibration purposes.

QUAL2E was calibrated to match the observed average dissolved oxygen concentrations measured at two locations (NGA-01, and NGA-JC-C1) on the mainstem of the creek. Data collected at station NGA-02 was used to characterize the upstream boundary conditions. The initial DO and ammonia calibration was deemed successful. Similarly, the initial coefficients used to describe chlorophyll a correctly replicated observed low observed field concentrations and confirmed that algal productivity was not an important component of the dissolved oxygen budget in the area downstream of the Johnston City STP discharge.

The reach-specific sediment oxygen demand values entered in the model for Reach 1 of 0.079 g/sq. ft./day was based on an SOD test run at NGA-02. The sediment oxygen demand values entered in the model for Reach 2 of 0.06 g/sq. ft./day was adjusted to match the observed downstream data. The resulting dissolved oxygen predictions compared well to the measured concentrations during the survey, as shown in Figure 4-4. The QUAL2E model output files from the calibration runs are included in Attachment 3.

Based on the components of dissolved oxygen mass balance in the QUAL2E model output files, the largest components of the oxygen deficit in the stream immediately downstream of the Johnston City STP were due to the sediment oxygen demand, and the oxygen consumed for nitrification of ammonia and nitrite. Although SOD is one of the dominant sources of the oxygen deficit, the true cause is a lack of base flow (which greatly exacerbates the effect of SOD).

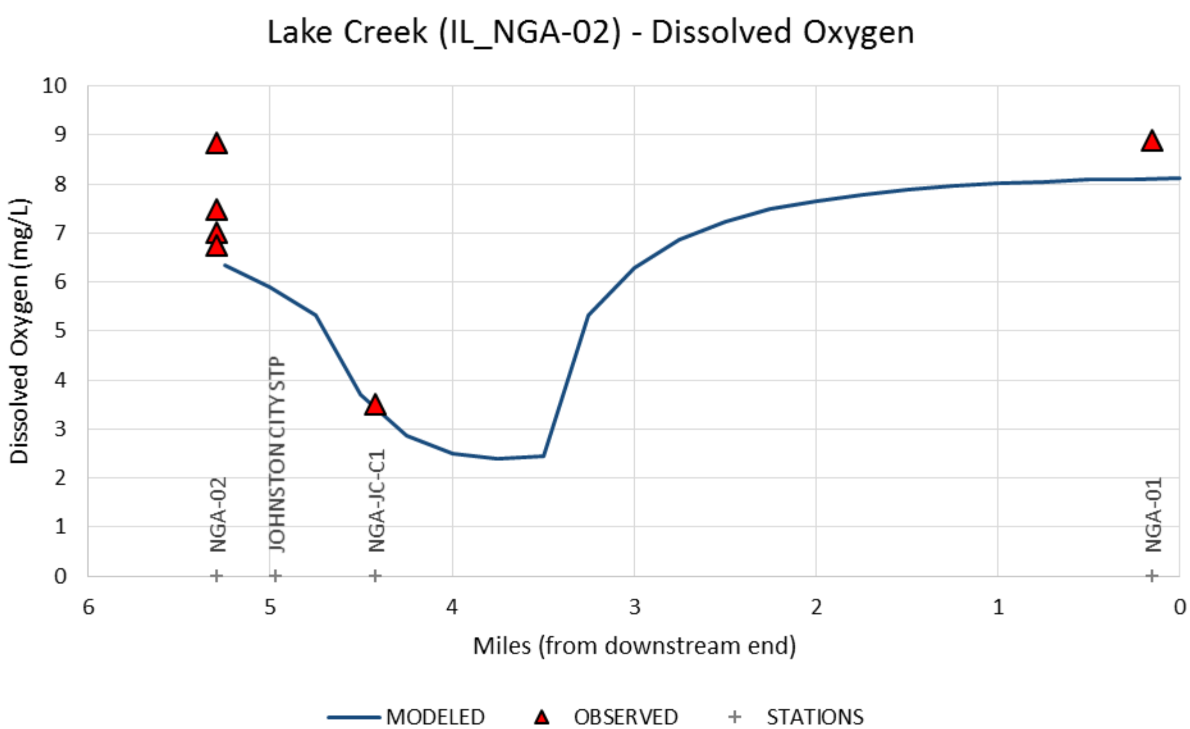

Figure 4-4. QUAL2E DO Calibration for Lake Creek for 9/24/2015 Sampling Survey

4.2 Load Duration Curve Approach

A load duration curve approach was used in the fecal coliform, sulfate, iron, chloride, and manganese analyses for streams in the Upper Big Muddy watershed. A load-duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over the entire range of flow conditions. The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems, as discussed immediately below;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below); and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

4.2.1 Model Selection

A detailed discussion of the model selection process for TMDL development in the Upper Big Muddy River watershed is provided in the Stage 1 Report. The load-duration curve approach was selected because it is a simpler approach that can be supported with the available data and still support the selected level of TMDL implementation for this TMDL. The load-duration curve approach identifies broad categories of pollutant sources and the extent of control required from these source categories to attain water quality standards.

4.2.2 Approach

The load duration curve approach uses stream flows for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by: 1) ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results; 2) translating the flow duration curve (produced in step 1) into a load duration curve by multiplying the flows by the water quality standard; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph. Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature. A more complete description of the load duration curve approach is provided in the Stage 1 Report.

4.2.3 Big Muddy R. / IL_N-11 – Fecal Coliform Load Duration Curve

This section describes the flow and water quality data used to support development of the load duration curve for fecal coliform bacteria on the above noted stream segment.

4.2.3.a Flow Data

Segment IL_N-11 of the Big Muddy River is located downstream of Rend Lake, so the flows in the river at that point are impacted by the reservoir storage and dam operations. When developing the load-duration curve, the reservoir storage can reduce the peak flows, and maintain a higher baseflow, making distinction between dry and wet weather related sources difficult to distinguish. To remedy that problem, daily flow measurements were used from the USGS gage on Casey Fork near Mount Vernon, IL (USGS gage number 05595820) for the period from 1999 through 2015.

Casey Fork is a tributary to the Big Muddy River upstream of Rend Lake, so flows at that location are not impacted by the reservior. This gage is located approximately 28.6 miles north of station N-11, where the water quality data was collected. This gage has a drainage area of 76.9 square miles, so all flow data from the gage are adjusted based on the drainage area ratio (DAR) to the stream segment under consideration. The drainage area within the Upper Big Muddy River watershed for segment IL-N-11 is 312.3 square miles, which does not include areas upstream of Rend Lake. The Casey Fork gage was selected based on the proximity to the stream segment under consideration, and that it is located within the same watershed, the fact that it is upstream of Rend Lake, so it is not impacted by the reservoir.

4.2.3.b Water Quality Data

Fecal coliform data collected at station N-11 by IEPA between 1999 and 2010 were used in the analysis. The data were collected as part of IEPA's ambient water quality monitoring program. Only data for the months of May-October were used because the water quality standard applies only during this period.

4.2.3.c Analysis

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. The load duration curve for fecal coliform were generated by multiplying the flows in the duration curve by the water quality standard of 200 cfu/100 mL for fecal coliform bacteria. The load duration curve for fecal coliform is shown with a solid line in Figure 4-5. Observed pollutant loads of fecal coliform were calculated using available concentration data paired with corresponding flows, and were plotted on the same graph. The fecal coliform data used only measurements collected between May and October, since that is the period specified under Section 302.209 of Title 35.

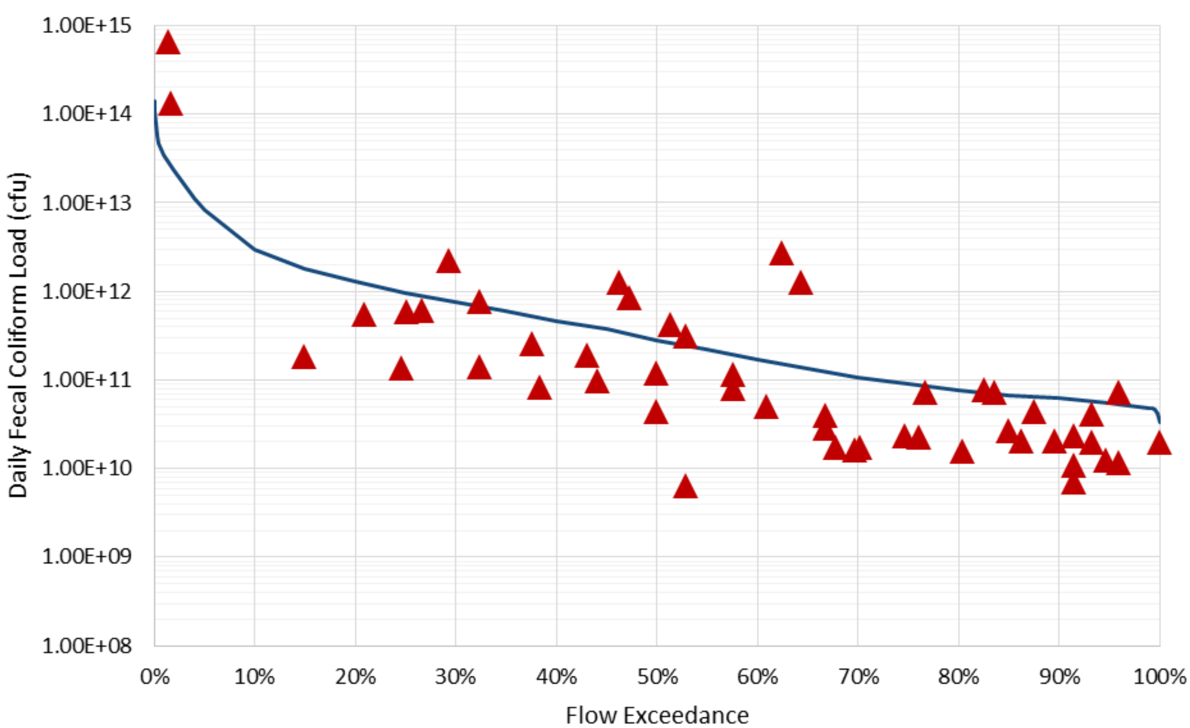

Figure 4-5. Fecal Coliform Load Duration Curve for Upper Big Muddy River (IL_N-11) with Observed Loads (triangles)

In Figure 4-5, the data show exceedances of the fecal coliform target occur over all ranges of flows, but with more exceedances (as a fraction of the samples) occuring in the higher range of flows. This indicates that wet weather sources contribute to the observed violations of the water quality standard.

4.2.4 Andy Cr. / IL_NZN-13 – Iron Load Duration Curve

This section describes the flow and water quality data used to support development of the load duration curve for dissolved iron on the above noted stream segment.

4.2.4.a Flow Data

There is no stream gage on Andy Creek that can be used to estimate the daily flows and loadings. Daily flow measurements are available for the USGS gage on Crab Orchard Creek near Marion, IL (USGS gage number 05597500) for the period from 1999 through 2015. This gage is located approximately 20.2 miles southeast of the Andy Creek watershed. This gage has a drainage area of 31.7 square miles, so all flow data from the gage are adjusted based on the drainage area ratio (DAR) to the stream segment under consideration. The stream segment under consideration has a drainage area of 20.4 square miles at its outlet. The Crab Orchard Creek gage was selected for consideration based on the drainage areas being similar in size, the proximity to the stream segment under consideration, with similar watershed land uses and topography.

4.2.4.b Water Quality Data

Dissolved iron data collected by IEPA in 2008 were used in the analysis. The data were collected as part of IEPA's ambient water quality monitoring program. There were three samples analyzed, and all three exceeded the water quality standards.

4.2.4.c Analysis

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. A load duration curve for iron was generated by multiplying the flows in the duration curve by the water quality standard of 1.0 mg/L for dissolved iron. The load duration curve for iron is shown with a solid line in Figure 4-6. Observed pollutant loads of dissolved iron were calculated using available concentration data paired with corresponding flows, and were plotted on the same graph.

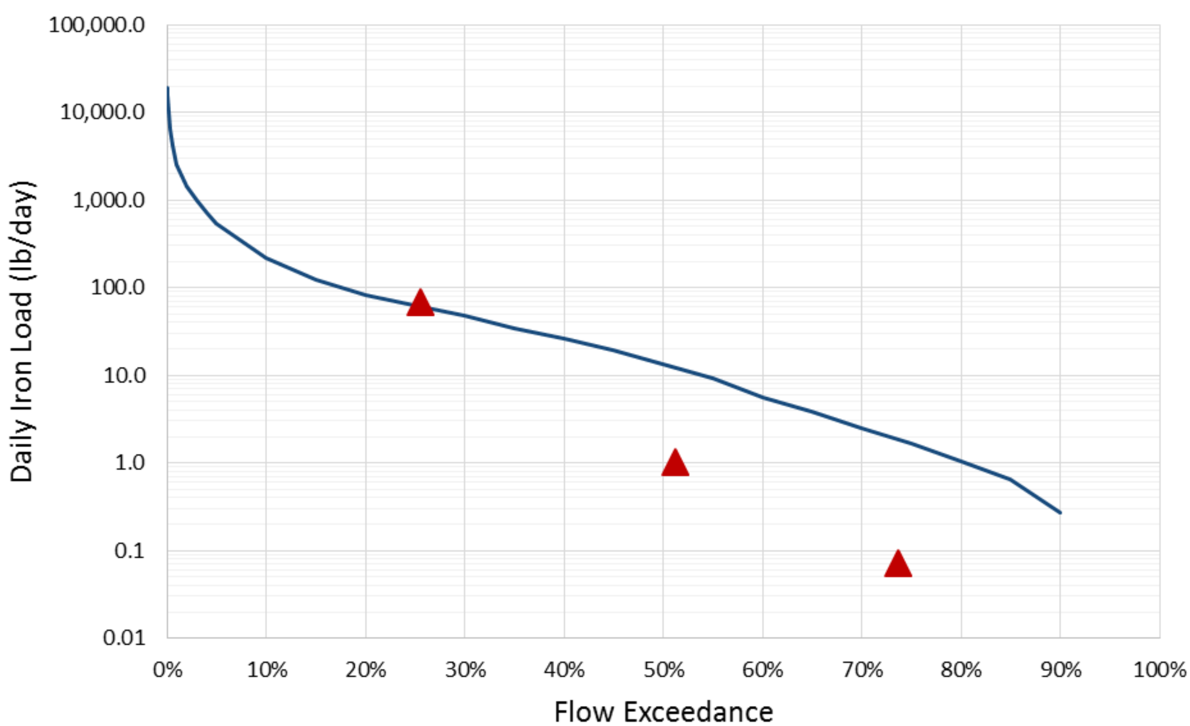

Figure 4-6: Dissolved Iron Load Duration Curve for Andy Creek (IL_NZN-13) with Observed Loads (triangles)

In Figure 4-6, the data show that the sampled data points only exceeded the dissolved iron target at the highest sampled flow. This indicates that wet weather sources or runoff contribute to the observed violation of the water quality standard.

4.2.5 Pond Cr. / IL_NG-02 – Chloride Load Duration Curve

This section describes the flow and water quality data used to support development of the load duration curve for fecal coliform bacteria on the above noted stream segment.

4.2.5.a Flow Data

Daily flow measurements are available for the USGS gage on Crab Orchard Creek near Marion, IL (USGS gage number 05597500) for the period from 1999 through 2015. This gage has a drainage area of 31.7 square miles, so all flow data from the gage are adjusted based on the drainage area ratio (DAR) to the stream segment under consideration.

4.2.5.b Water Quality Data

Fecal coliform data collected by IEPA between 1999 and 2006 were used in the analysis. The data were collected as part of IEPA's ambient water quality monitoring program. Only data for the months of May-October were used because the water quality standard applies only during this period.

4.2.5.c Analysis

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. The load duration curve for chloride was generated by multiplying the flows in the duration curve by the water quality standard 500 mg/L for chloride. The load duration curve for chloride is shown with a solid line in Figure 4-7. Observed pollutant loads of chloride were calculated using available concentration data paired with corresponding flows, and were plotted on the same graph.

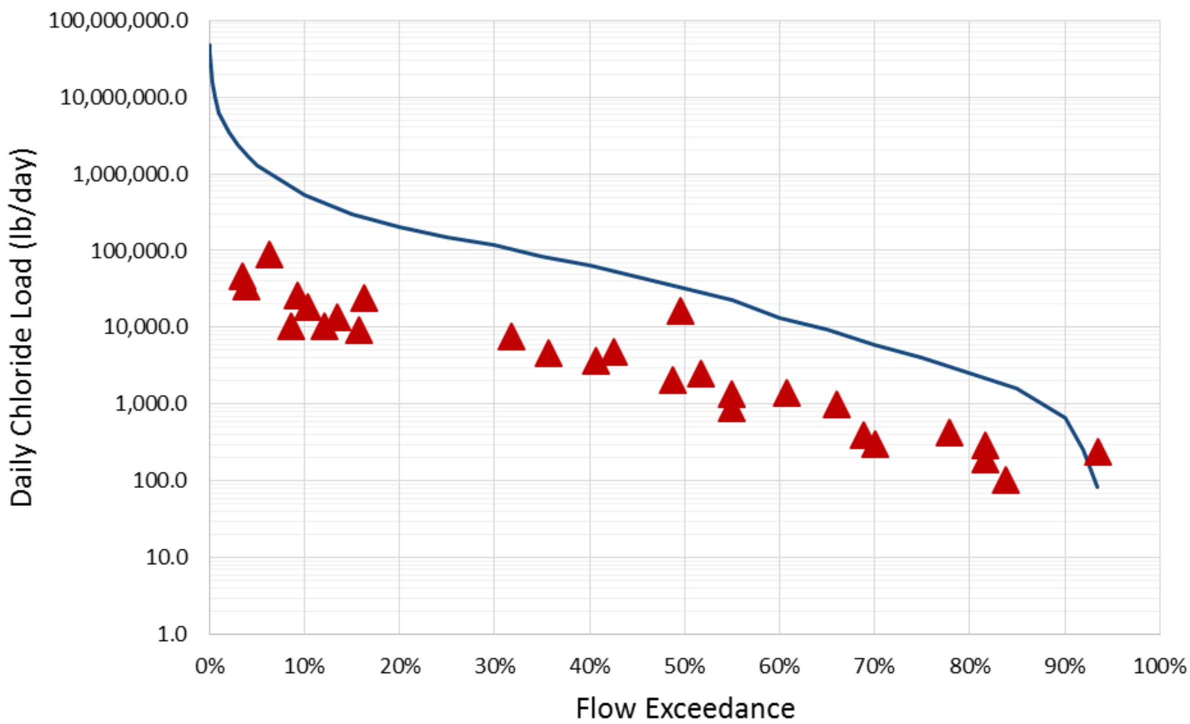

Figure 4-7: Chloride Load Duration Curve for Pond Creek (IL_NG-02) with Observed Loads (triangles)

In Figure 4-7, the data show that the single exceedance of the chloride target occurs at the lowest sampled flow. This indicates that wet weather sources do not contribute to the observed violation of the water quality standard. With the single data point showing an exceedance of the water quality standard for Chloride occurring at the very lowest flows, this indicates that the impairment may be flow related. Before implementing a TMDL for this stream segment, additional monitoring is recommended to confirm that the impairment is related to a pollutant load source, and is not only related to very low flow conditions in the stream. Additional monitoring recommendations are contained in the Watershed Implementation Plan to achieve the TMDLs and Load Reduction Strategy in the Upper Big Muddy River watershed.

4.2.6 Beaver Cr. / IL_NGAZ-JC-D1 – Manganese Load Duration Curve

This section describes the flow and water quality data used to support development of the load duration curve for manganese on the above noted stream segment.

4.2.6.a Flow Data

Daily flow measurements are available for the USGS gage on Crab Orchard Creek near Marion, IL (USGS gage number 05597500) for the period from 1999 through 2015. This gage has a drainage area of 31.7 square miles, so all flow data from the gage are adjusted based on the drainage area ratio (DAR) to the stream segment under consideration.

The stream gage data shows that there are periods where there is no flow in the stream, This does not necessarily mean that the stream dries up, but the flows are below the threshold for stream measurement. This causes the load-duration curve to be equal to zero during these time periods.

4.2.6.b Water Quality Data

Manganese data collected by IEPA in 2008 were used in the analysis. There is only a single data point available for this analysis.

4.2.6.c Analysis

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. The load duration curve for manganese was generated by multiplying the flows in the duration curve by the chronic water quality standard of 4.85 mg/L, which was calculated based on a hardness measurement of 383 mg/L that was field measured at the same time at the manganese measurement in this stream segment. The load duration curve for manganese is shown with a solid line in Figure 4-8. Observed pollutant loads were calculated using available concentration data paired with corresponding flows, and were plotted on the same graph.

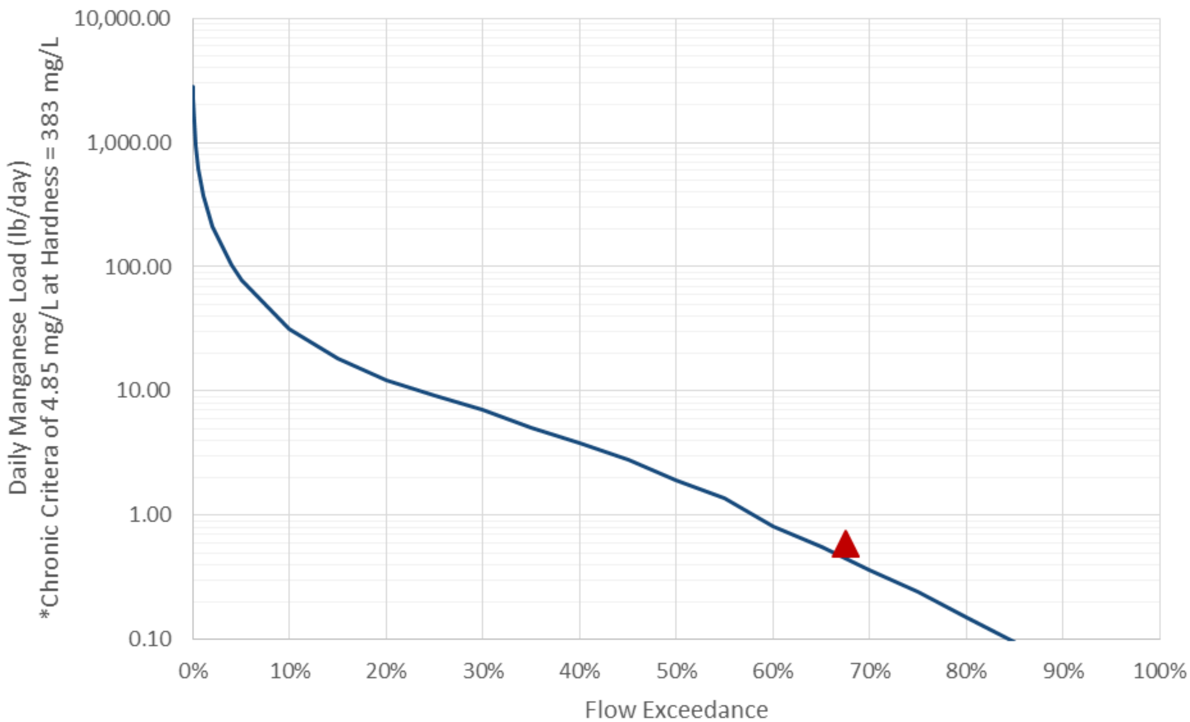

Figure 4-8: Manganese Load Duration Curve for Beaver Creek (IL_NGAZ-JC-D1 with Observed Loads (triangles)

In Figure 4-8, the data show that the single exceedance of the manganese target occurs at the lower end of the normally encountered flows (30% to 70%).

4.2.7 M. Fk. Big Muddy / IL_NH-06 – Fecal Coliform Load Duration Curve

This section describes the flow and water quality data used to support development of the load duration curve for fecal coliform bacteria on the above noted stream segment.

4.2.7.a Flow Data

There is no stream gage on this segment of the Middle Fork of the Big Muddy River that can be used to estimate the daily flows and loadings. Daily flow measurements are available for the USGS gage on Casey Fork near Mount Vernon, IL (USGS gage number 05595820) for the period from 1999 through 2015. Casey Fork is a tributary to the Big Muddy River upstream of Rend Lake, so flows at that location are not impacted by the reservoir storage and dam operations. This gage is located approximately 23.3 miles north of station NH-06, where the water quality data was collected. This gage has a drainage area of 76.9 square miles, so all flow data from the gage are adjusted based on the drainage area ratio (DAR) to the stream segment under consideration. The stream segment under consideration has a drainage area of 160.6 square miles at its outlet.

4.2.7.b Water Quality Data

Fecal coliform data collected at station NH-06 by IEPA between 1999 and 2010 were used in the analysis. The data were collected as part of IEPA's ambient water quality monitoring program. Only data for the months of May-October were used because the water quality standard applies only during this period.

4.2.7.c Analysis

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. The load duration curve for fecal coliform were generated by multiplying the flows in the duration curve by the water quality standard of 200 cfu/100 mL for fecal coliform bacteria. The load duration curve for fecal coliform is shown with a solid line in Figure 4-9. Observed pollutant loads of fecal coliform were calculated using available concentration data paired with corresponding flows, and were plotted on the same graph. The fecal coliform data used only measurements collected between May and October, since that is the period specified under Section 302.209 of Title 35.

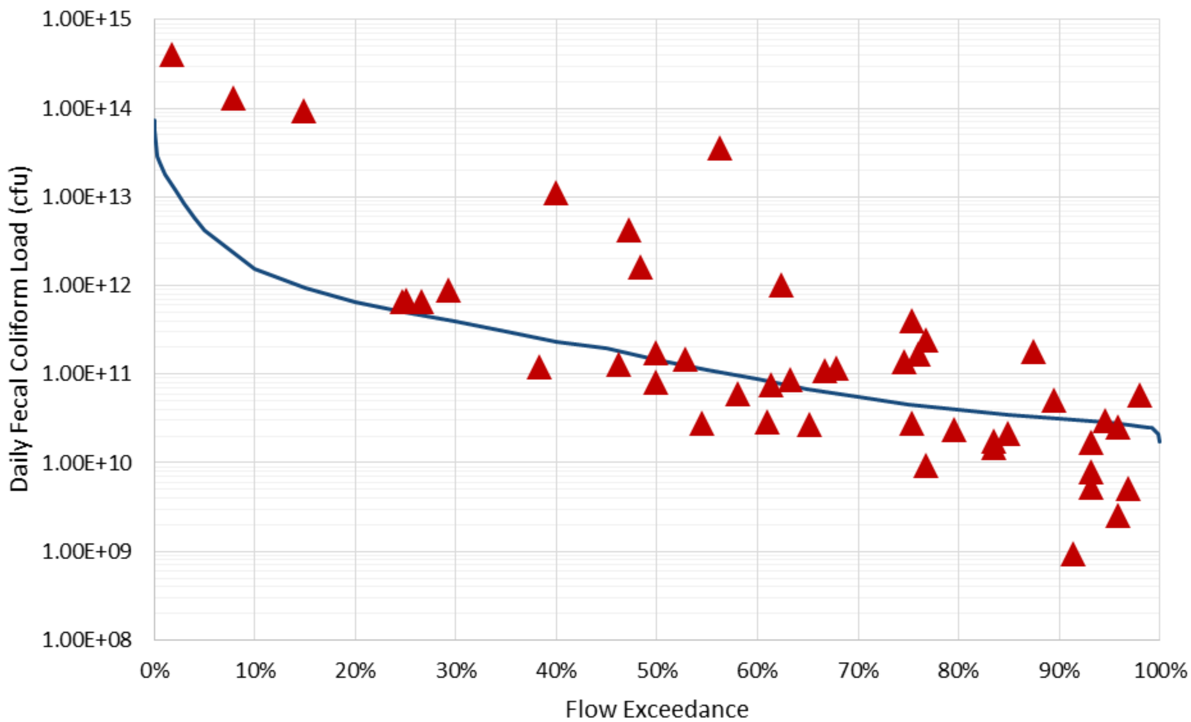

Figure 4-9. Fecal Coliform Load Duration Curve for Middle Fork Big Muddy River (IL_N-11) with Observed Loads (triangles)

In Figure 4-9, exceedances of the fecal coliform target occur over all ranges of flows, but with more exceedances in the higher range of flows. This indicates that wet weather sources are a contributing factor to the observed violations of the water quality standard, but that significant dry weather reductions are necessary as well.

4.3 BATHTUB Model

The BATHTUB model (Walker, 1986) was selected as the tool to define load reduction necessary to attain phosphorus targets in the following lakes/reservoirs located in the Upper Big Muddy River watershed:

- Herrin Old / IL_RNZD
- Johnston City / IL_RNZE
- Arrowhead (Williamson) / IL_RNZX
- West Frankfort Old / IL_RNP
- West Frankfort New/ IL_RNQ

4.3.1 Model Selection

A detailed discussion of the model selection process is provided in the Stage 1 report (Attachment 1). BATHTUB is a simple modeling tool that can predict the relationship between phosphorus load and resulting in-lake phosphorus concentrations. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed lake data. BATHTUB has been used previously for several reservoir TMDLs in Illinois, and has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited (Ernst et al., 1994).

BATHTUB is a software program for predicting the lake/reservoir response to nutrient loading. Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus.

BATHTUB contains a number of empirical regression equations that have been calibrated using a wide range of lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, chlorophyll concentrations, and Secchi depth (transparency). Both tabular and graphical displays are available from the program.

4.3.2 Modeling Approach

The approach taken for the total phosphorus TMDLs consisted of using existing empirical data to define current loads to each of the lakes, and using the BATHTUB model to define the extent to which these loads must be reduced to meet water quality standards. This approach was taken because phosphorus concentrations exceed the water quality standards, often by significant amounts. Phosphorus loads will need to be reduced to a fraction of existing load in order to attain water quality standards.

4.3.3 BATHTUB Model Inputs

This section gives an overview of the model inputs required for BATHTUB application, and how they were derived for application to the reservoirs on this project. The following categories of inputs are required for BATHTUB:

- Model Options
- Global Variables
- Reservoir Segmentation
- Tributary Loads

  The model options and global variables applied universally across the 5 lakes that were modeled in BATHTUB for this this project. Those are discussed below, with the descriptions of the reservoir segmentation and tributary loads in each model contained in separate sections of this report.

4.3.3.a Model Options

BATHTUB provides a multitude of model options to estimate nutrient concentrations in a reservoir. Model options were entered as shown in Table 4-5, and the rationale for these options discussed below. No conservative substance was being simulated, so this option was not needed. The Canfield and Bachman phosphorus option was selected for phosphorus, as this is a commonly used formulation for Midwestern phosphorus TMDLs (e.g. MPCA, 2007; https://www.pca.state.mn.us/sites/default/files/wq-iw8-03e.pdf) Nitrogen was not simulated because phosphorus is the nutrient of concern.

Chlorophyll a and transparency were not simulated because the water quality target is specified as total phosphorus. The Fischer numeric dispersion model was selected, which is the default approach in BATHTUB for defining mixing between lake segments. Phosphorus calibrations were based on lake concentrations. No nitrogen calibration was required. The use of availability factors was not required and estimated concentrations were used to generate mass balance Tables.

Table 4-5. BATHTUB Model Options

Model	Model Option
Conservative substance	Not computed
Total phosphorus	Canfield and Bachman
Total nitrogen	Not computed
Chlorophyll-a	Not computed
Transparency	Not computed
Longitudinal dispersion	Fischer-numeric
Phosphorus calibration	Concentrations
Nitrogen calibration	None
Error analysis	Model and Data
Availability factors	Ignored
Mass-balance Tables	Use estimated concentrations

4.3.3.b Global Variables

The global variables required by BATHTUB consist of:

- The averaging period for the analysis
- Precipitation, evaporation, and change in lake levels
- Atmospheric phosphorus loads

BATHTUB is a steady state model, whose predictions represent concentrations averaged over a period of time. One decision in the application of BATHTUB is the selection of length of time over which inputs and outputs should be modeled. An annual averaging period was used for all lakes in the Upper Big Muddy watershed, consistent with the fact that tributary loading estimates represented annual average conditions.

There was no assumed increase in storage during the modeling period, to represent steady state conditions. The values selected for precipitation and change in lake levels have little influence on model predictions. Atmospheric phosphorus loads were specified using default values provided by BATHTUB.

4.3.3.c Reservoir Segmentation

BATHTUB provides the capability to divide the reservoir under study into a number of individual segments, allowing prediction of the change in phosphorus concentrations over the length of each segment. The segmentation scheme selected for the lakes modeled was designed to provide at least two segments per lake, to include segment representing the deeper conditions near the dam, and at least one upstream segment, depending on the lake and the conficuration of the primary lake sampling stations.

Table 4-6. BATHTUB Model Segmentation

Lake / Reservoir	Total Size (ac)	Model Segments
Herrin Old / IL_RNZD	51.3	2
Johnston City / IL_RNZE	64	2
Arrowhead (Williamson) / IL_RNZX	30	3
West Frankfort Old / IL_RNP	146	2
West Frankfort New/ IL_RNQ	214	3

The areas of the segments and the watersheds for the segments were determined by Geographic Information System (GIS), and maps are provided for each of the lakes provided below.

BATHTUB requires that a range of inputs be specified for each segment. These include segment surface area, length, total water depth, and depth of thermocline and mixed layer. Segment-specific values for segment depths (total, thermocline and mixed layer) were calculated from the lake monitoring data, while segment lengths and surface areas were calculated via GIS.

4.3.3.d Tributary Loads

BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Tributary and direct drainage flows to each segment were estimated using observed flows at the USGS gaging station at on Crab Orchard Creek near Marion, IL (USGS gage number 05597500), adjusted through the use of drainage area ratios as follows:

Flow into segment = Flow at USGS gage * Segment-specific drainage area ratio

Drainage area ratio = Drainage area of watershed contributing to model segment

Drainage area of watershed contributing to USGS gage

Segment-specific drainage area ratios were calculated via GIS information.

Total phosphorus concentrations for each tributary and direct drainage inflow were estimated by dividing the watershed phosphorus load (calculated based on land use and literature phosphorus loading rates) by the tributary flow.

Average total phosphorus concentrations = Annual watershed phosphorus loads / Annual tributary flow

A complete listing of all segment-specific flows and tributary concentrations is provided in Attachment 4.

4.3.4 BATHTUB Calibration

BATHTUB model calibration consists of:

1. Applying the model with all inputs specified as above
2. Comparing model results to observed phosphorus data
3. Adjusting model coefficients to provide the best comparison between model predictions and observed phosphorus data.

Additional site-sprecific information on the calibration of the BATHTUB model application for each reservoir in the Upper Big Muddy River watershed is given in the sections below.

4.3.5 Herrin Old / IL_RNZD BATHTUB Model Application

Herrin Old Reservoir is a 51 acre lake located in Williamson County, Illinois. It is approximately 21 feet deep at its deepest point near the dam at the downstream side of the lake. Herrin Old Lake requires a TMDL for total phosphorus.

The listing and recommendation of a TMDL for total phosphorus in the Stage 1 report was based on a single water quality sample taken in 2011 that exceeded the water quality standard of 0.05 mg/L. Additional data from 2012 and 2013 was provided by IEPA for the modeling and TMDL preparation. The new data shows that the water quality sampled at the upstream stations (RNZD02 & RNZD-3) all met the water quality standards. These were all sampled at a depth of 1 ft. The only samples taken during this period that exceeded the water quality standard we taken at station RNZD-1 at depths near the bottom of the reservoir. This indicates that the internal phosphorus loading from sedimants is the primary source contributing to the impairment of the water body.

4.3.5.a Reservoir Segmentation

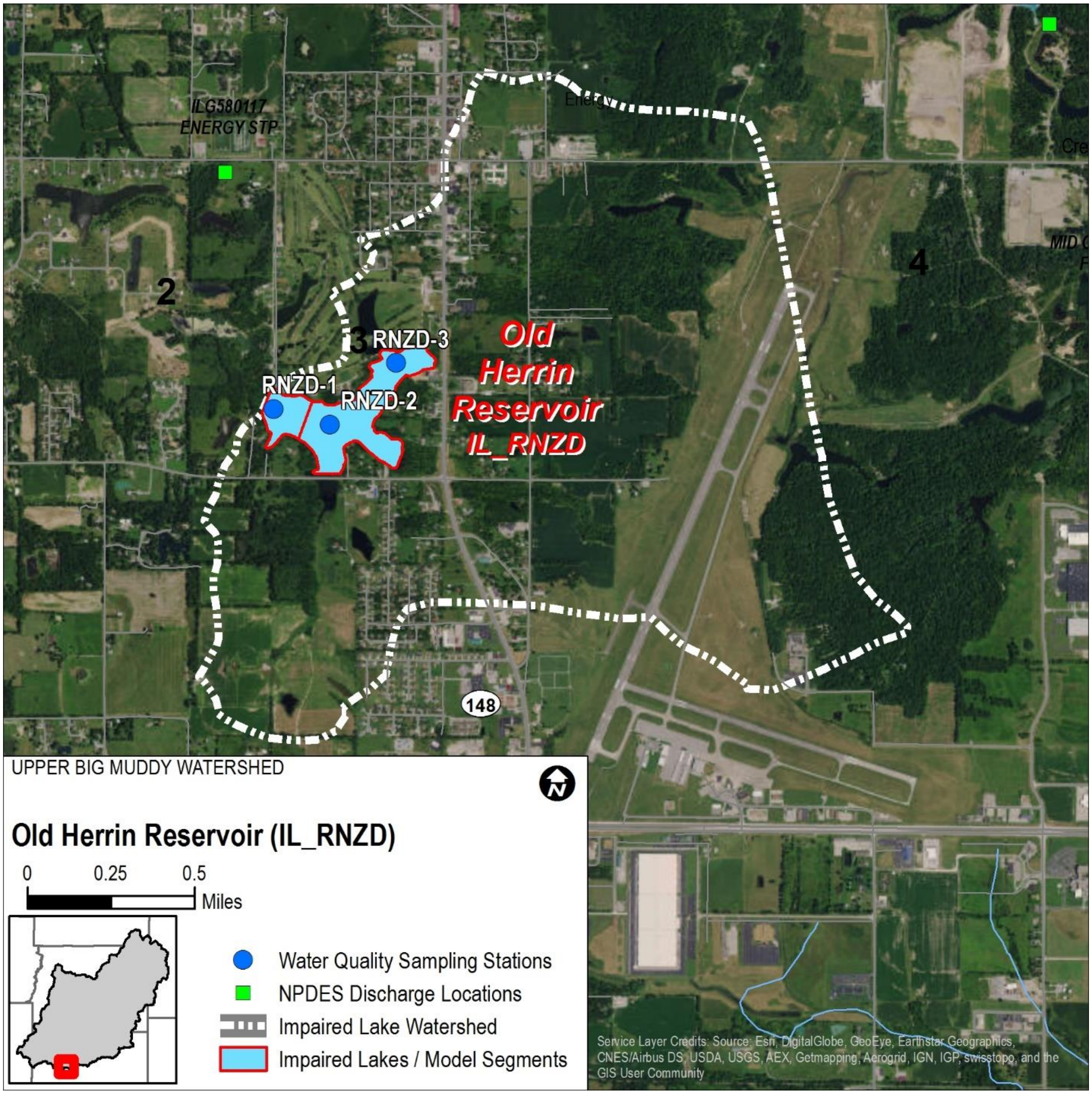

Figure 4-10. Old Herrin Reservoir (IL_RNZD) Segmentation Used in BATHTUB Model

4.3.5.b Tributary Loads

BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Tributary and direct drainage flows to each segment were estimated using observed flows at the USGS gaging station at on Crab Orchard Creek near Marion, IL (USGS gage number 05597500), adjusted through the use of drainage area ratios as described in section 4.3.3.d above.

Annual average flow from the contributing watershed calculated using the above method was 3.2 cfs, and the annual average total phosphorus concentrations (calculated based on land use and literature phosphorus loading rates) 0.029 mg/L. This correlated well with the observed total phosphorus concentrations at the upstream sampling stations (RNZD-2 and RNZD-3). The total estimated annual watershed load is 84.3 kg/yr of total phosphorus.

A complete listing of all segment-specific flows and tributary concentrations is provided in Attachment 4.

4.3.5.c BATHTUB Calibration

The BATHTUB model was initially applied with the model inputs as specified above. Observed lake data for the year 2012 were used for calibration purposes.

BATHTUB was calibrated to match the observed reservoir-average phosphorus concentrations. Model results using default model parameters initially under-predicted the observed phosphorus, i.e. model predictions were lower than observed concentrations. Phosphorus loss rates in BATHTUB reflect a typical "net settling rate" (i.e. settling minus sediment release) observed in a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data was corrected via the addition of an internal phosphorus load of 12 mg/m²/day in the downstream model segment (Segment 1). This internal load estimate was adjusted during the model calibration to match th observed data. The resulting modeled and observed total phosphorus concentrations are shown in Figure 4-11. BATHTUB output files are provided in Attachment 4.

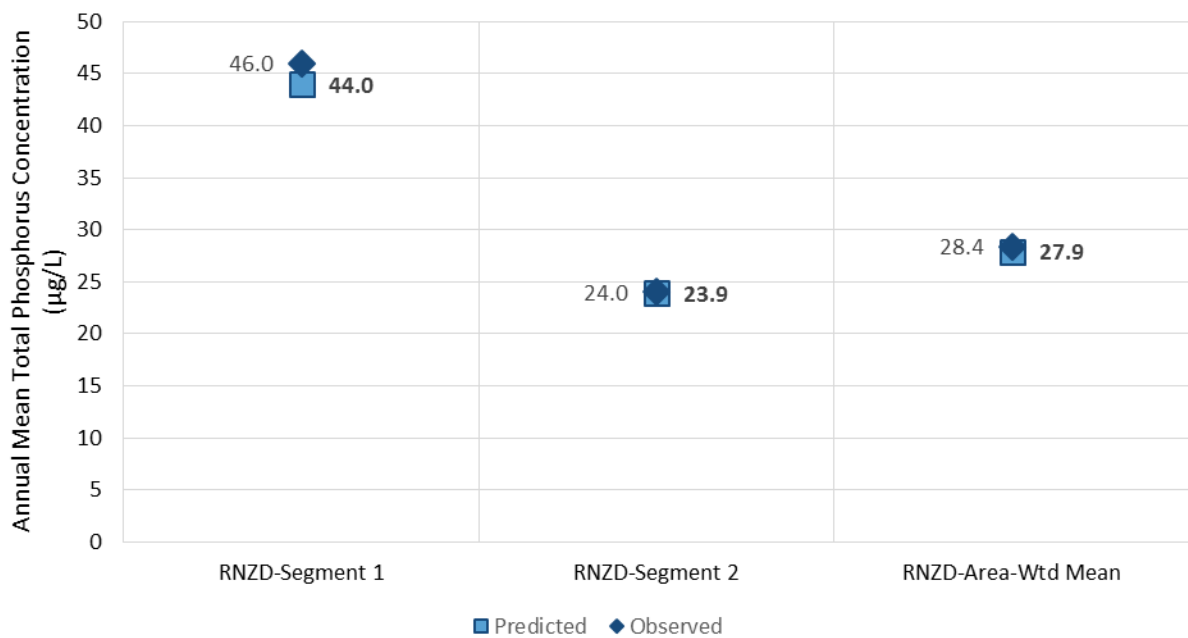

Figure 4-11. Herrin Old (IL_RNZD) BATHTUB Segment Modeled vs. Observed Total Phosphorus Concentration

4.3.6 Johnston City / IL_RNZE BATHTUB Model Application

Johnston City Lake / IL_RNZE is an impoundment of Lake Creek; it is just east of Freeman No. 4 Mine. The lake requires a TMDL for total phosphoru. The most recent water quality data for Johnston City Lake is from 2002. There are three sampling stations located within the lake, as shown in Figure 4-12 below.

4.3.6.a Reservoir Segmentation

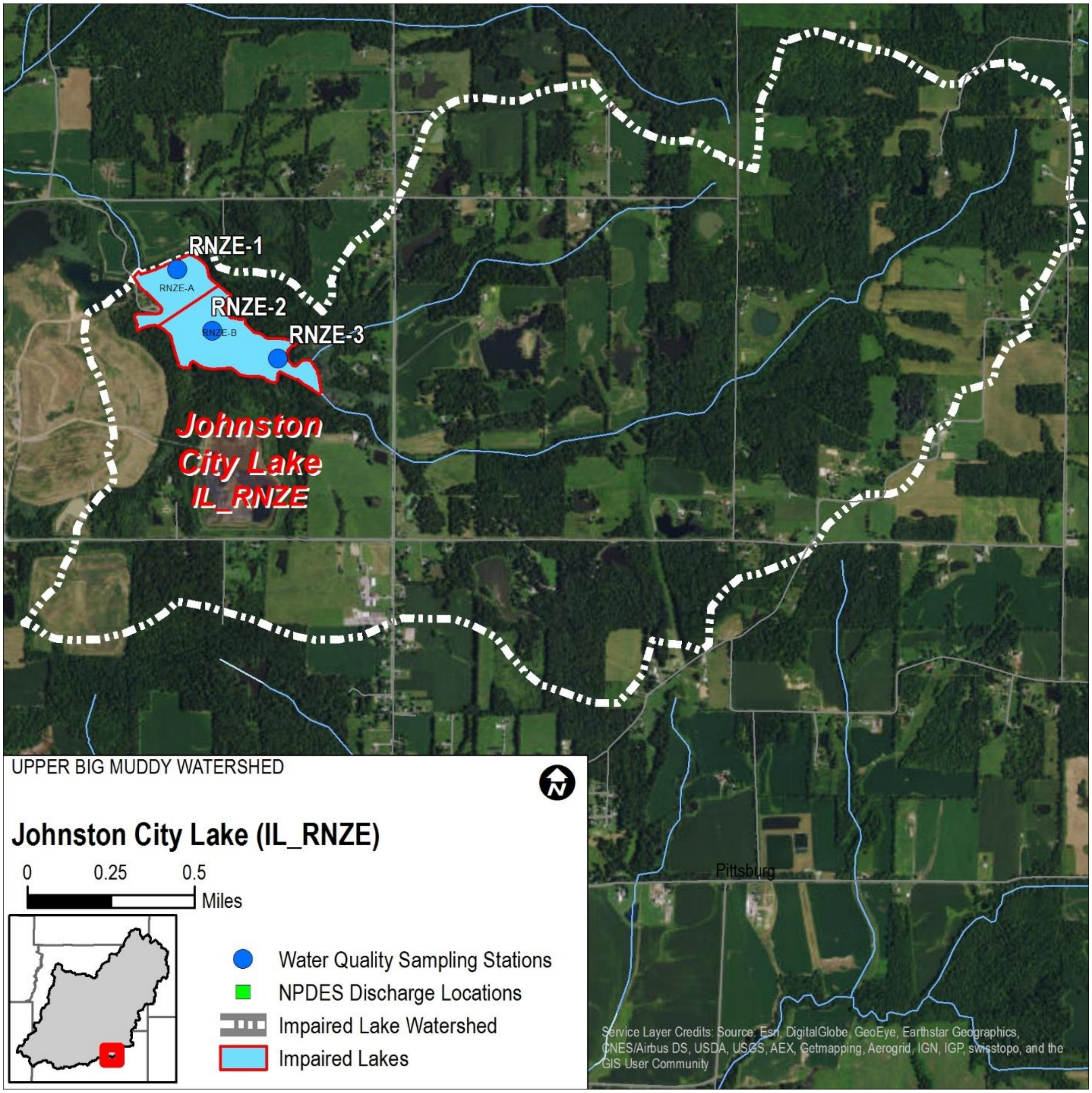

Figure 4-12. Johnston City Lake (IL_RNZE) Segmentation Used in BATHTUB Model

4.3.6.b Tributary Loads

BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Tributary and direct drainage flows to each segment were estimated using observed flows at the USGS gaging station at on Crab Orchard Creek near Marion, IL (USGS gage number 05597500), adjusted through the use of drainage area ratios as described in section 4.3.3.d above.

Annual average flow from the contributing watershed calculated using the above method was 4.9 cfs, and the annual average total phosphorus concentrations (calculated based on land use and literature phosphorus loading rates) 0.040 mg/L. The total estimated annual watershed load is 175.5 kg/yr of total phosphorus.

A complete listing of all segment-specific flows and tributary concentrations is provided in Attachment 4.

4.3.6.c BATHTUB Calibration

The BATHTUB model was initially applied with the model inputs as specified above. Observed lake data for the year 2002 were used for calibration purposes.

BATHTUB was calibrated to match the observed reservoir-average phosphorus concentrations. Model results using default model parameters initially under-predicted the observed phosphorus, i.e. model predictions were lower than observed concentrations. Phosphorus loss rates in BATHTUB reflect a typical "net settling rate" (i.e. settling minus sediment release) observed in a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data was corrected via the addition of an internal phosphorus load of 2 mg/m^2/day in the upstream model segment (Segment 2). The resulting modeled and observed total phosphorus concentrations are shown in Figure 4-13. BATHTUB output files are provided in Attachment 4.

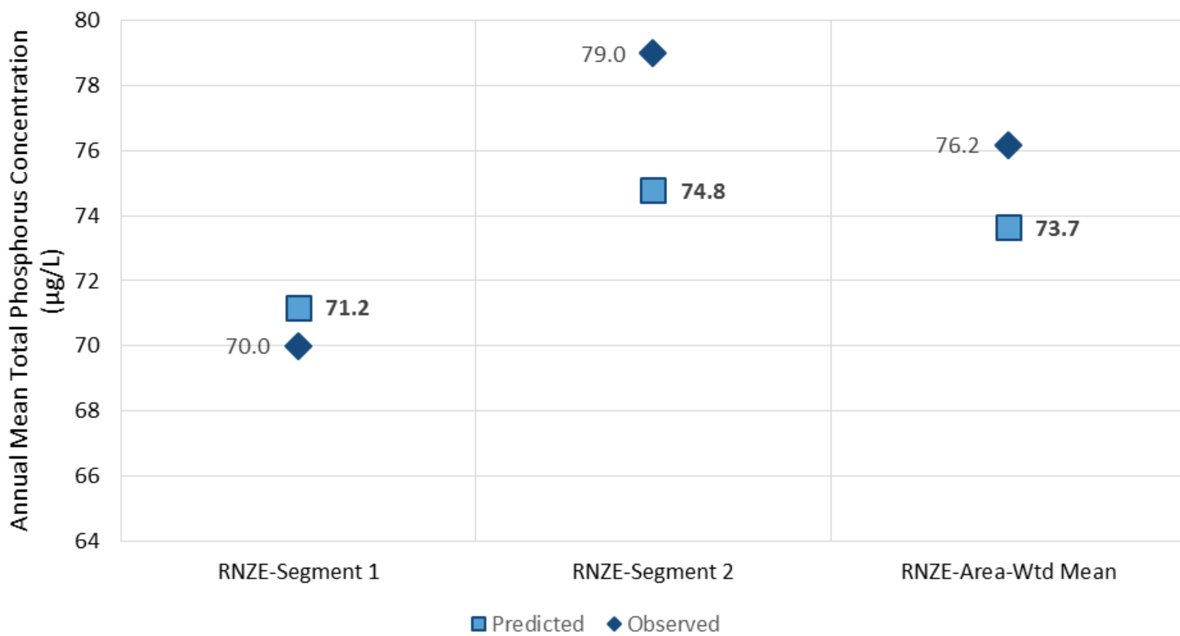

Figure 4-13. Johnston City Lake (IL_RNZE) BATHTUB Segment Modeled vs. Observed Total Phosphorus Concentration

4.3.7 Arrowhead (Williamson) / IL_RNZX BATHTUB Model Application

Arrowhead Lake (Williamson) / IL_RNZX is located just northeast of Johnston City, near Shakerag, IL. Arrowhead requires a TMDL for total phosphorus.

4.3.7.a Reservoir Segmentation

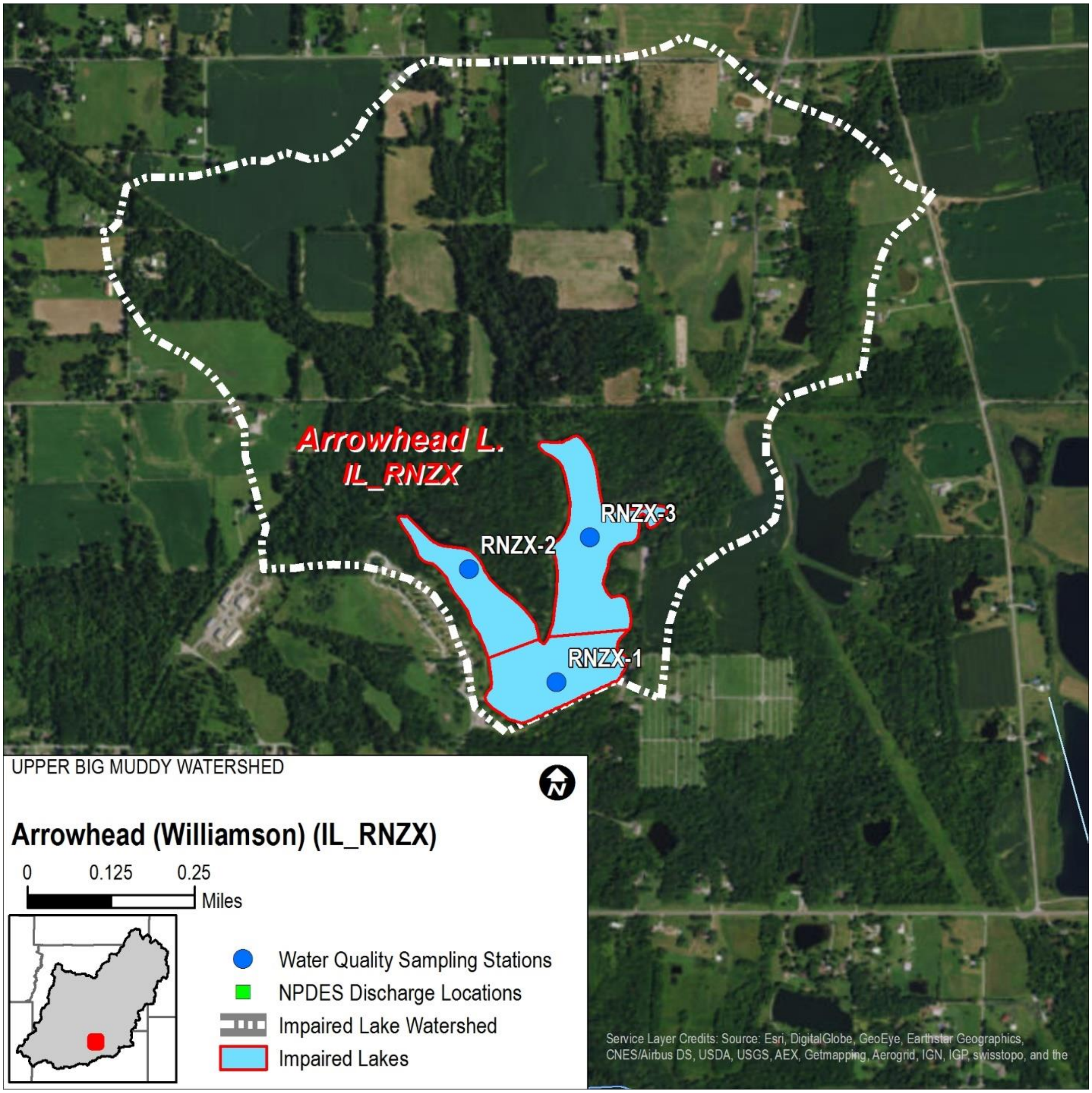

Figure 4-14. Arrowhead (Williamson) (IL_RNZX) Segmentation Used in BATHTUB Model

4.3.7.b Tributary Loads

BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Tributary and direct drainage flows to each segment were estimated using observed flows at the USGS gaging station at on Crab Orchard Creek near Marion, IL (USGS gage number 05597500), adjusted through the use of drainage area ratios as described in section 4.3.3.d above.

Annual average flow from the contributing watershed calculated using the above method was 1.0 cfs, and the annual average total phosphorus concentration (calculated based on land use and literature phosphorus loading rates) was 0.046 mg/L. The total estimated annual watershed load is 39.7 kg/yr of total phosphorus.

A complete listing of all segment-specific flows and tributary concentrations is provided in Attachment 4.

4.3.7.c BATHTUB Calibration

The BATHTUB model was initially applied with the model inputs as specified above. Observed lake data for the year 2013 were used for calibration purposes.

BATHTUB was calibrated to match the observed reservoir-average phosphorus concentrations. Model results using default model parameters initially under-predicted the observed phosphorus, i.e. model predictions were lower than observed concentrations. Phosphorus loss rates in BATHTUB reflect a typical "net settling rate" (i.e. settling minus sediment release) observed in a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data was corrected via the addition of an internal phosphorus load of 12 mg/m²/day. The resulting modeled and observed total phosphorus concentrations are shown in Figure 4-15. BATHTUB output files are provided in Attachment 4.

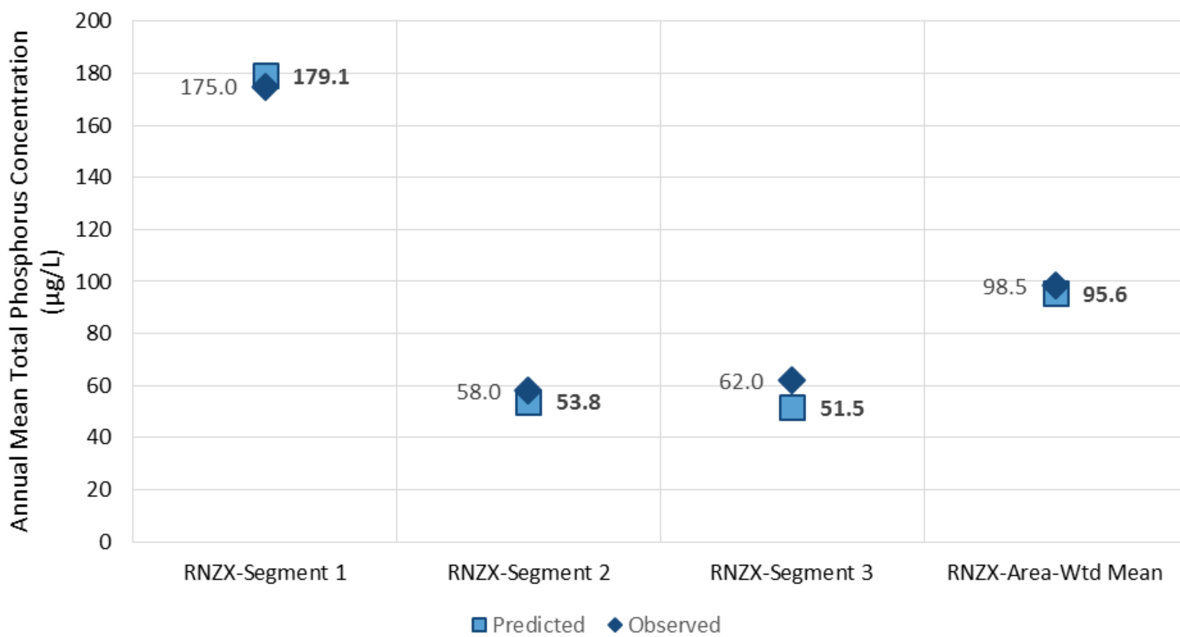

Figure 4-15. Arrowhead (Williamson) (IL_RNZX) BATHTUB Segment Modeled vs. Observed Total Phosphorus Concentration

4.3.8 West Frankfort Old / IL_RNP BATHTUB Model Application

West Frankfort Old City Lake is a 147 acre impoundment located approcimately 6 miles east of the West Frankfort in Franklin County that requires a TMDL for total phosphorus. The water quality data used to develop the BATHTUB model was collected in 2008 and 2013.

4.3.8.a Reservoir Segmentation

The BATHTUB model for the West Franklin Old Reservior, was developed with two model segments as shown in Figure 4-16, one representing the upstream monitoring stations (RNP-2 & RNP-3), and one representing the downstream station at the deepest portion of the lake (RNP-1).

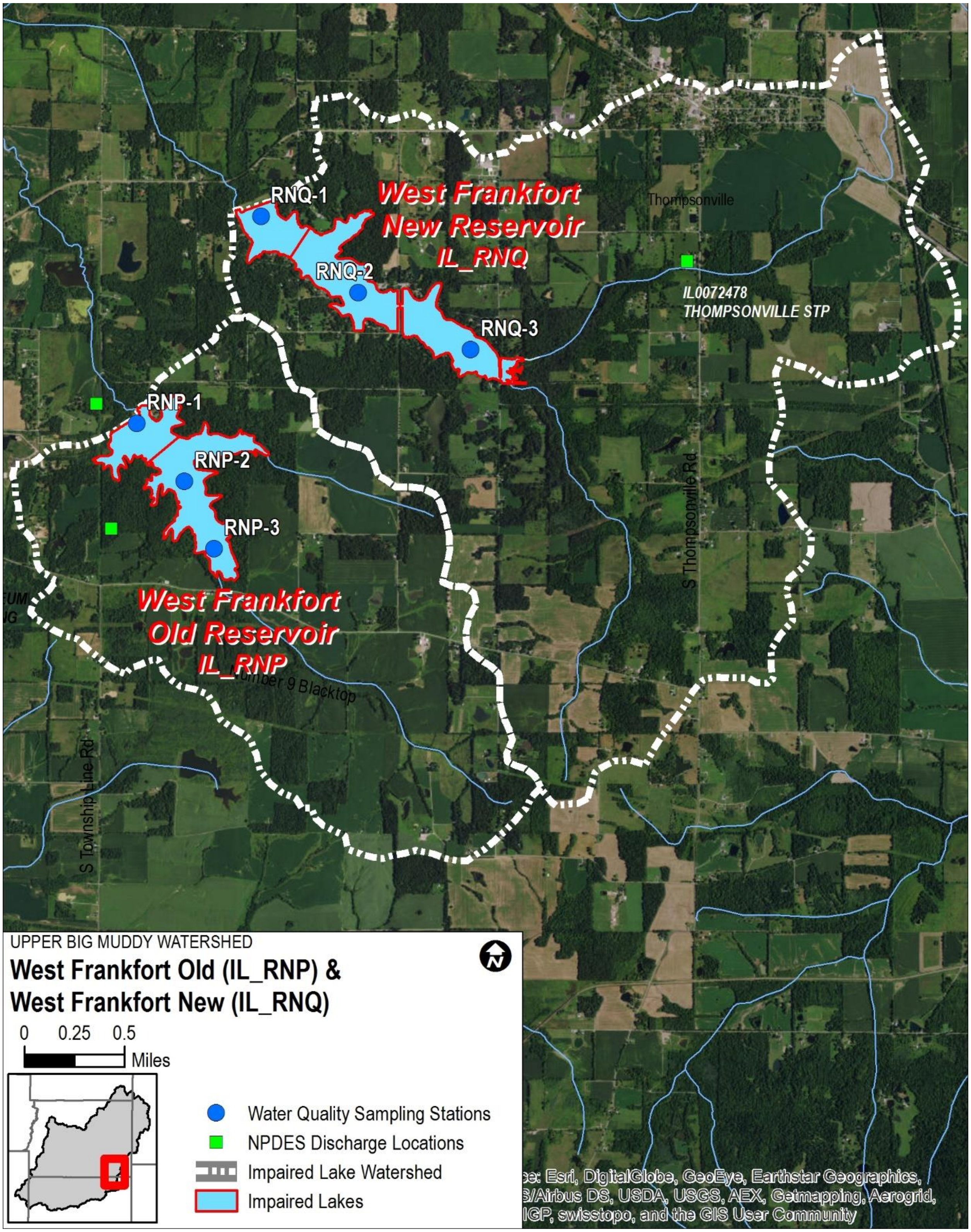

Figure 4-16. West Frankfort Old (IL_RNP) and West Frankfort New (IL_RNQ) Lake Segmentation Used in BATHTUB

4.3.8.b Tributary Loads

BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Tributary and direct drainage flows to each segment were estimated using observed flows at the USGS gaging station at on Crab Orchard Creek near Marion, IL (USGS gage number 05597500), adjusted through the use of drainage area ratios as described in section 4.3.3.d above.

Annual average flow from the contributing watershed calculated using the above method was 5.0 cfs, and the annual average total phosphorus concentration (calculated based on land use and literature phosphorus loading rates) was 0.164 mg/L. The total estimated annual watershed load is 725.5 kg/yr (1599.5 lb/year) of total phosphorus.

4.3.8.c BATHTUB Calibration

The BATHTUB model was initially applied with the model inputs as specified above. Observed lake data for the years 2008 and 2013 were used for calibration purposes.

BATHTUB was calibrated to match the observed reservoir-average phosphorus concentrations. Model results using default model parameters initially under-predicted the observed phosphorus, i.e. model predictions were lower than observed concentrations. Phosphorus loss rates in BATHTUB reflect a typical "net settling rate" (i.e. settling minus sediment release) observed in a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data was corrected via the addition of an internal phosphorus load of 40 mg/m²/day in the downstream segment (Segment 1). The resulting modeled and observed total phosphorus concentrations are shown in Figure 4-17. BATHTUB output files are provided in Attachment 4.

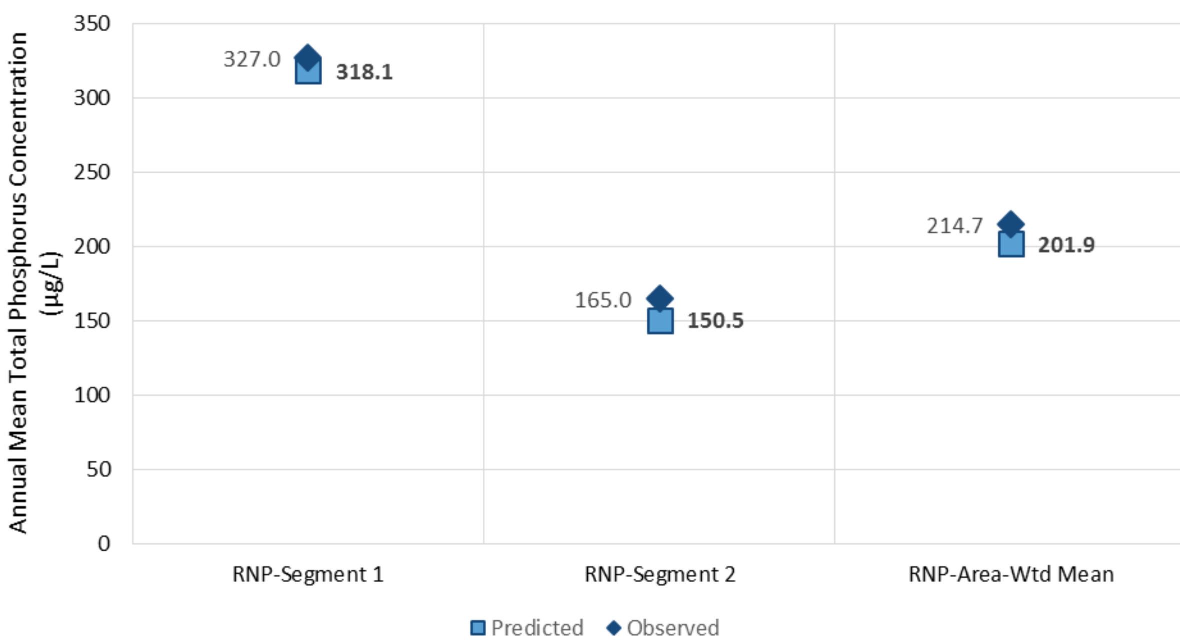

Figure 4-17. West Frankfort Old (IL_RNP) BATHTUB Segment Modeled vs. Observed Total Phosphorus Concentration

4.3.9 West Frankfort New/ IL_RNQ BATHTUB Model Application

4.3.9.a Reservoir Segmentation

West Frankfort New reservoir is located northeast of West Franklin Old Reservior, as shown in Figure 4-16. The BATHTUB model was developed with three model segments, one for each of the primary monitoring station in the lake.

4.3.9.b Tributary Loads

BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Tributary and direct drainage flows to each segment were estimated using observed flows at the USGS gaging station at on Crab Orchard Creek near Marion, IL (USGS gage number 05597500), adjusted through the use of drainage area ratios as described in section 4.3.3.d above.

Annual average flow from the contributing watershed calculated using the above method was 10.0 cfs, and the annual average total phosphorus concentration (calculated based on land use and literature phosphorus loading rates) was 0.101 mg/L. The total estimated annual watershed load is 906.2 kg/yr of total phosphorus.

In addition to the watershed loads, there is a point source load from the Thompsonville STP (IL0072478). The design average flow (DAF) for the facility is 0.08 million gallons per day (MGD) and the design maximum flow (DMF) for the facility is 0.20 MGD. Treatment consists of two cell aerated lagoon and rock filter.

The average daily flows from this STP reported in the DMRs from 2008 through 2016 0.087 MGD. There is no water quality data for total phosphorus from this point source to use for model calibration. The total phosphorus concentration in the STP effluent was assumed to be 3.66 mg/L. With the monthly average flows reported on the DMRs for that facility, the annual average loading is 437.4 kg/yr.

Based on the combined flow and loads from the sources identified above, the total annual average concentration into the reservoir is 0.148 mg/L, with a total annual loading of 1343.6 kg/yr.

4.3.9.c BATHTUB Calibration

The BATHTUB model was initially applied with the model inputs as specified above. Observed lake data for the year 2013 were used for calibration purposes.

BATHTUB was calibrated to match the observed reservoir-average phosphorus concentrations. Model results using default model parameters initially under-predicted the observed phosphorus, i.e. model predictions were lower than observed concentrations. Phosphorus loss rates in BATHTUB reflect a typical “net settling rate” (i.e. settling minus sediment release) observed in a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data was corrected via the addition of internal phosphorus loads of 25 mg/m^2/day in Segment 3 (upstream), 35 mg/m^2/day in Segment 2, and 90 mg/m^2/day in Segment 1 (downstream). The resulting modeled and observed total phosphorus concentrations are shown in Figure 4-18. BATHTUB output files are provided in Attachment 4.

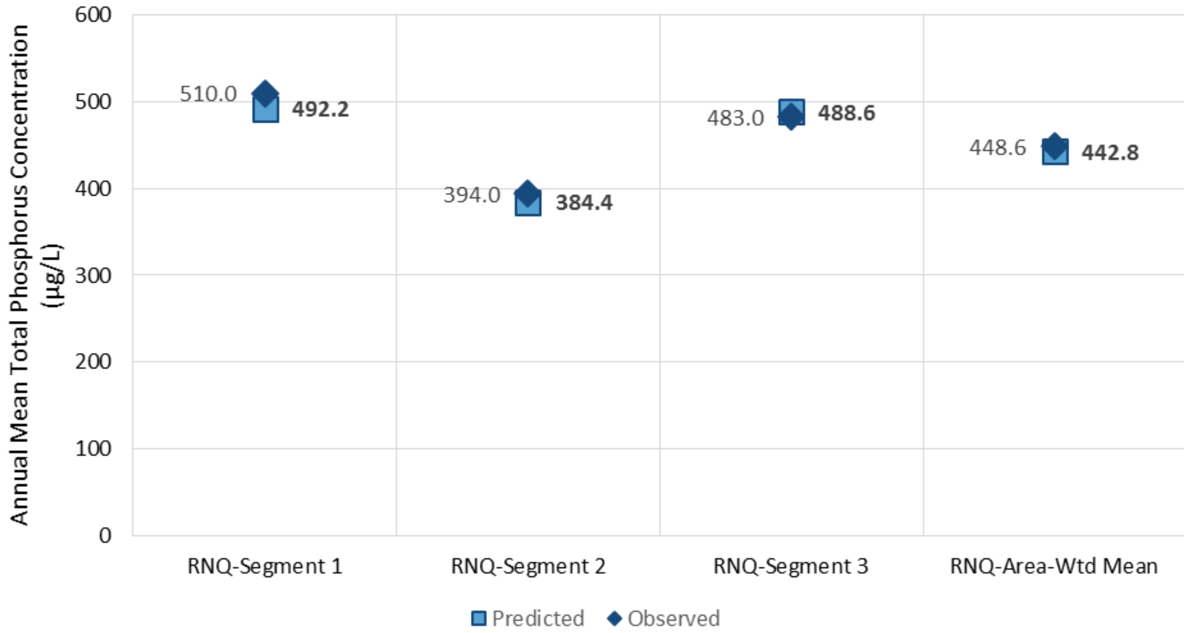

Figure 4-18. West Frankfort New (IL_RNQ) BATHTUB Segment Modeled vs. Observed Total Phosphorus Concentration

4.4 Total Suspended Solids Model for Load Reduction Strategy Development

This section describes the model selection and modeling approach for the total suspended solids load reduction strategy for the following waterbodies in the Upper Big Muddy River watershed, identified by IEPA as being impaired due to elevated total suspended solids concentrations:

- Herrin Old / IL_RNZD
- Johnston City / IL_RNZE
- West Frankfort Old / IL_RNP
- West Frankfort New/ IL_RNQ
- Big Muddy R. / IL_N-06
- Big Muddy R. / IL_N-11
- Big Muddy R. / IL_N-17
- Hurricane Creek / IL_NF-01
- Pond Cr. / IL_NG-02
- M. Fk. Big Muddy / IL_NH-07

4.4.1 Modeling Approach

The total suspended solids load reduction strategy is based on a simple empirical model using the average of all available TSS data on each waterbody, and comparing it with the LRS endpoint concentration identified in Section 3.1.

The load reduction target concentration for TSS for all streams in this watershed is 27.75 mg/L. For all lakes in the watershed, the load reduction targets concentration is 23 mg/L.

After reviewing the water quality data available, it was found that the following waterbodies have average TSS concentrations already below the target for the watershed, and therefore will not have LRSs prepared.

- Herrin Old / IL_RNZD
- Johnston City / IL_RNZE
- West Frankfort Old / IL_RNP
- West Frankfort New/ IL_RNQ
- Hurricane Creek / IL_NF-01

5 TMDL Development for the Upper Big Muddy River Watershed

This section presents the development of the TMDLs for the following waterbodies in the Upper Big Muddy River watershed:

- Upper Big Muddy River (IL_N-11) for fecal coliform
- Andy Cr. (IL_NZN-13) for iron.
- Lake Cr. (IL_NGA-02) for dissolved oxygen.
- Beaver Cr. (IL_NGAZ-JC-D1) for manganese.
- Middle Fork Big Muddy (IL_NH-06) for fecal coliform.
- Arrowhead (Williamson) (IL_RNZX) for total phosphorus.
- Herrin Old (IL_RNZD) for total phosphorus.
- Johnston City (IL_RNZE) for total phosphorus.
- West Frankfort Old (IL_RNP) for total phosphorus.
- West Frankfort New (IL_RNQ) for total phosphorus.

In addition, a dissolved oxygen TMDL was planned for Andy Creek (IL_NZN-13), but after reviewing the field data and developing the QUAL2E model, it was determined that the low flows and high sediment oxygen demand were the primary causes of the low dissolved oxygen in this stream, not external pollutant loadings.

5.1 Andy Creek (IL_NZN-13) Dissolved Oxygen TMDL

A dissolved oxygen assessment was conducted for Andy Creek segment IL_NZN-13. The result of this assessment indicates that low stream flows preclude attainment of dissolved oxygen standards, even in the complete absence of external pollutant loads. For this reason, a TMDL is not being developed for dissolved oxygen. Details of the assessments are discussed below.

Two lines of assessment were used to make the determination that it is low stream flows, rather than external pollutant loads, that precludes attainment of dissolved oxygen standards:

1. Sediment oxygen demand is the dominant component of the dissolved oxygen mass balance provided by QUAL2E.
2. Setting all external loading sources to zero in the QUAL2E model does not result in attainment in dissolved oxygen standards.
3. Leaving all external loads at currently specified values, but increasing base stream flow, does result in attainment with dissolved oxygen standards.

5.1.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

The first step in determining the loading capacity was to reduce external sources of oxygen-demanding substances to determine whether these reductions would result in the river attaining the dissolved oxygen target.

QUAL2E simulations showed that, even with incremental inflow and permitted BOD loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results showed that sediment oxygen demand was the dominant source of the oxygen deficit, and that DO standards could only be attained during critical periods via reduction of SOD[1].

5.2 Lake Creek (IL_NGA-02) Dissolved Oxygen TMDL

A dissolved oxygen assessment was conducted for Lake Creek segment IL_NGA-02 utilizing the data collected in September 2015 and a QUAL2E model. The QUAL2E model was calibrated to the data available, which occurred during a month when there were effluent limit violations from the Johnston City STP for both CBOD5 and ammonia nitrogen.

To determine if the effluent violations were causing the observed DO impairments, the QUAL2E model was run with modifying the input loads from the Johnston City STP to the current permit limits of 10 mg/L $CBOD_5$ (monthly average effluent limit) and 1.5 mg/L ammonia nitrogen (monthly average effluent limit), and 6.0 mg/L of dissolved oxygen (monthly average minimum) at the design average flow for the facility of 0.55 MGD.

The result of this assessment shows that if the Johnston City STP effluent meets the above noted limits. The dissolved oxygen concentration in the stream reaches a minimum level of 5.37 mg/L, which is above the 5.0 mg/L endpoint selected for the TMDL based on the State of Illinois water quality standards.

5.2.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

The first step in determining the loading capacity was to reduce external sources of oxygen-demanding substances to determine whether these reductions would result in the river attaining the dissolved oxygen target.

QUAL2E simulations showed that with the point load $CBOD_5$ and ammonia nitrogen loads set to zero, compliance with the dissolved oxygen standards was attained with a minimum dissolved oxygen concentration of 5.38 mg/L.

Further QUAL2E simulations with adjusted BOD, dissolved oxygen, and ammonia nitrogen loads from the Johnston City STP were performed to determine the loading capacity. As noted above, QUAL2E model simulations with the input loads from the Johnston City STP set ther current permit limits of 10 mg/L $CBOD_5$ (monthly average effluent limit) and 1.5 mg/L ammonia nitrogen (monthly average effluent limit), and 6.0 mg/L of dissolved oxygen (monthly average minimum) at the design average flow for the facility of 0.55 MGD resulted in a minimum dissolved oxygen concentration of 5.37 mg/L, which is above the 5.0 mg/L endpoint selected for the TMDL based on the State of Illinois water quality standards.

Additional QUAL2E simulations were performed with the input loads from the Johnston City STP adjusted until the minimum dissolved oxygen concentration was 5.0 mg/L to determine the maximum loading capacity of the stream. The loading capacity of the stream for ammonia nitrogen was determined

[1] Although SOD is the dominant source of the oxygen deficit, the true cause of low dissolved oxygen is a lack of base flow (which greatly exacerbates the effect of SOD). Because TMDLs cannot be written to control flow, no TMDL was developed for this stream segment.

to be 1.80 mg/L, with a $CBOD_5$ load of 11 mg/L, and 5.45 mg/L of dissolved oxygen at the design average flow for the facility. The total loading capacity for Lake Creek segment IL_NGA-02 for ammonia nitrogen is 8.25 lb/day.

5.2.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

The WLA for the Johnston City STP into Lake Creek segment IL_NGA-02 was calculated based on the permitted design average flow for the facility, and the current NPDES effluent limit concentration for ammonia nitrogen of 1.5 mg/L (monthly average limitation). The WLA for Lake Creek is presented in Table 5-1.

Table 5-1. Lake Creek Segment IL_NGA-02 Watershed Permitted Dischargers and WLAs

NPDES ID	Facility Name	Ammonia Nitrogen Effluent Concentration (mg/L)	Design average flow (MGD)	WLA (lb/day)
ILG0029301	Johnston City STP	1.50	0.55	6.88

The remaining loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The load allocation for nonpoint sources is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a total loading capacity of 8.25 lbs/day of ammonia nitrogen, a WLA for the Johnston City STP of 6.88 lbs/day, and an explicit margin of safety of 10% (discussed below), the load allocation for Lake Creek segment IL_NGA-02 is 0.54 lbs/day.

5.2.3 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The QUAL2E model and the sampling were performed during a low flow period, which is critical for determining loads associated with low dissolved oxygen.

5.2.4 Margin of Safety

The TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the QUAL2E water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the stream, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit total ammonia nitrogen load allocated to the margin of safety is 0.825 lbs/day for Lake Creek.

5.2.5 Reserve Capacity

Lake Creek is located in Williamson County, the population of which has increased by 8.3% between 2000 and 2010 (Stage 1 Report Section 2.6). In 2010, the U.S. Census Bureau estimated the Franklin County population at 66,357.

The Illinois Department of Public Health population projections (Shahidullah 2015) for Williamson County shows a slight population increase to 69,246 in the year 2025. Further, the Greater Egypt Regional Planning and Development Commission, referencing US Census Bureau projections, states that the population in the Greater Egypt 5-county area which includes Williamson County will be relatively steady (or slightly declining) through 2030 (GERPDC 2010).

A reserve capacity is not needed, due to the slight projected increase in population, and because, at this time IEPA is not aware of any increases in discharges from the existing point sources, or the establishment of future municipal or industrial point sources.

5.2.6 TMDL Summary

The dissolced oxygen (ammonia) TMDL for Lake Creek segment IL_NGA-02, is presented in Table 5-2.

Table 5-2. Lake Creek IL_NGA-02 TMDL Summary

Allocation	Total Ammonia Nitrogen Load (lbs/day)
Load Capacity (LC)	8.25
Wasteload Allocation (WLA)	6.88
Load Allocation (LA)	0.54
Margin of safety (10% of LC)	0.83

5.3 Upper Big Muddy River (IL_N-11) Fecal Coliform TMDL

A load capacity calculation approach was applied to support development of a fecal coliform TMDL for Upper Big Muddy River segment IL_N-11.

5.3.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

The loading capacity for Upper Big Muddy River segment IL_N-11 was defined over a range of specified flows based on expected Upper Big Muddy River flows at the mouth of the creek. The allowable loading capacity was computed by multiplying flow by the TMDL target (200 cfu/100 mL). The fecal coliform loading capacity for IL_N-11 is presented in Table 5-3.

Table 5-3. Fecal Coliform Load Capacity (IL_N-11)

Flow Exceedance Percentile from the LDC	Upper Big Muddy River Flow (cfs)	Allowable Load (cfu/day)
99%	9.7	4.8E+10
95%	11	5.6E+10
90%	13	6.2E+10
80%	16	7.7E+10
70%	22	1.1E+11
60%	35	1.7E+11
50%	57	2.8E+11
40%	93	4.6E+11
30%	150	7.6E+11
20%	260	1.3E+12
10%	610	3.0E+12
5%	1700	8.3E+12
1%	7200	3.5E+13

The maximum fecal coliform concentrations recorded between May and October were examined for each flow duration interval, as shown in Table 5-4, in order to estimate the percent reduction in existing loads required to meet the 200 cfu/100 mL target. As shown in Table 5-4, a greater reduction is needed at higher river flows to meet the target. During these higher flow periods, fecal coliform measurements were observed to exceed 200 cfu/100 mL more frequently.

Table 5-4. Required Reductions in Existing Loads under Different Flow Conditions (IL_N-11)

Flow Percentile Interval	Upper Big Muddy River Flow (cfs)	# samples > 200/ # samples (May-Oct)	Maximum fecal coliform concentration (cfu/100 ml)	Percent Reduction to Meet Target
0 - 30	28,875 - 154	3 / 8	4,500	95.6%
30 - 70	154 - 21.9	7 / 22	3,600	94.4%
70 - 100	21.9 - 6.9	1 / 15	210	4.8%

5.3.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

The WLA for the 10 permitted sewage treatment plant discharges in the Upper Big Muddy River segment IL_N-11 watershed was calculated based on the permitted design average flow for these dischargers and a fecal coliform concentration that is consistent with meeting the TMDL target (200 cfu/100mL). Eight of the ten NPDES-permitted dischargers have disinfection exemptions, therefore, the WLA is based on the dischargers meeting 200 cfu/100 mL at the downstream end of their exempted reach. WLAs are presented in Table 5-5.

Table 5-5. Segment IL_N-11 Watershed Permitted Dischargers and WLAs

NPDES ID	Facility Name	Disinfection exemption?	Design average flow (MGD)	WLA (cfu/day)
ILG580083	VALIER STP	Yes, year-round	0.08	6.06E+08
ILG580215	WEST CITY STP	Yes, year-round	0.1	7.57E+08
ILG580221	HANAFORD STP	Yes, year-round	0.042	3.18E+08
ILG580272	ORIENT STP	Yes, year-round	0.0752	5.69E+08
IL0050466	LB CAMPING-SESSER STP	No (400 cfu / 100 mL Daily Max)	0.0051	3.86E+07
IL0061760	HILL CITY APARTMENTS-BENTON	Yes, year-round	0.004	3.03E+07
IL0065111	REND LAKE CONS. DIST. STP	Yes, year-round	0.5	3.79E+09
IL0020851	CHRISTOPHER STP	Yes, year-round	0.768	5.81E+09
IL0022365	BENTON NORTHWEST STP	No (400 cfu / 100 mL Daily Max)	1.01	7.65E+09
IL0031704	WEST FRANKFORT STP	Yes, year-round	1.4	1.06E+10

The total WLA for the ten (10) point source dischargers in the IL_N-11 watershed is 3.02E+10 cfu/day. This does not include any dischargers in the areas upstream of Rend Lake. The significant retention time and settling capacity in the reservior are assumed to reduce fecal coliform loads from the upstream areas to be below the water quality standards.

The remainder of the loading capacity is given to the load allocation for nonpoint sources as an implicit MOS was used in this TMDL (Table 5-6). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall fecal coliform load.

Table 5-6. Fecal Coliform TMDL for Segment IL_N-11 Upper Big Muddy River[1]

Upper Big Muddy River Flow (cfs)	Allowable Load (cfu/day)	Wasteload Allocation (WLA) (cfu/day)	Load Allocation (LA) (cfu/day)
12.6	6.16E+10	3.02E+10	3.14E+10
15.8	7.75E+10	3.02E+10	4.73E+10
21.9	1.07E+11	3.02E+10	7.71E+10
34.9	1.71E+11	3.02E+10	1.41E+11
56.9	2.78E+11	3.02E+10	2.48E+11
93.4	4.57E+11	3.02E+10	4.27E+11
154	7.55E+11	3.02E+10	7.25E+11
260	1.27E+12	3.02E+10	1.24E+12
609	2.98E+12	3.02E+10	2.95E+12
7226	3.54E+13	3.02E+10	3.53E+13

[1]This TMDL has an implicit Margin of Safety, so MOS is not included in this table.

5.3.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figure 4-5 provides a graphical depiction of the data compared to the load capacity, showing that exceedances of the TMDL target occur over the full range of flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions; therefore critical conditions were addressed during TMDL development.

5.3.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The load capacity calculation approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in any given point in the season where the standard applies.

5.3.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The fecal coliform TMDL contains an implicit margin of safety, through the use of multiple conservative assumptions. First, the TMDL target (no more than 200 cfu/100 mL at any point in time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 mL for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. This margin of safety can be reviewed in the future as new data are developed.

5.4 Middle Fork Big Muddy (IL_NH-06) Fecal Coliform TMDL

A load capacity calculation approach was applied to support development of a fecal coliform TMDL for Middle Fork Big Muddy River segment IL_NH-06.

5.4.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

The loading capacity for the Middle Fork Big Muddy River segment IL_NH-06 was defined over a range of specified flows based on expected flows at the outlet of the segment. The allowable loading capacity was computed by multiplying flow by the TMDL target (200 cfu/100 mL). The fecal coliform loading capacity for IL_NH-06 is presented in Table 5-7.

Table 5-7. Fecal Coliform Load Capacity (IL_NH-06)

Flow Exceedance Percentile from the LDC	Middle Fork Big Muddy River Flow (cfs)	Allowable Load (cfu/day)
99%	5.0	2.5E+10
95%	5.8	2.9E+10
90%	6.5	3.2E+10
80%	8.1	4.0E+10
70%	11	5.5E+10
60%	18	8.8E+10
50%	29	1.4E+11
40%	48	2.4E+11
30%	79	3.9E+11
20%	130	6.5E+11
10%	310	1.5E+12
5%	870	4.2E+12
1%	3700	1.8E+13

The maximum fecal coliform concentrations recorded between May and October were examined for each flow duration interval, as shown in Table 5-8, in order to estimate the percent reduction in existing loads required to meet the 200 cfu/100 mL target. As shown in Table 5-8, the greatest reduction is needed at normally encountered river flows to meet the target. During these higher flow periods, fecal coliform measurements were observed to exceed 200 cfu/100 mL more frequently (as a fraction of the samples taken).

Table 5-8. Required Reductions in Existing Loads under Different Flow Conditions (IL_NH-06)

Flow Percentile Interval	Upper Big Muddy River Flow (cfs)	# samples > 200/ # samples (May-Oct)	Maximum fecal coliform concentration (cfu/100 ml)	Percent Reduction to Meet Target
0 - 30	14,849 - 79	7 / 7	20,000	99.0%
30 - 70	79 - 11.3	10 / 18	63,600	99.7%
70 - 100	11.3 - 3.55	7 / 21	1,760	88.6%

5.4.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

The WLA for the 3 permitted sewage treatment plant discharges in the Middle Fork Big Muddy River segment IL_NH-06 watershed was calculated based on the permitted design average flow for these dischargers and a fecal coliform concentration that is consistent with meeting the TMDL target (200 cfu/100mL). All three of these NPDES-permitted dischargers have disinfection exemptions, therefore, the WLA is based on the dischargers meeting 200 cfu/100 mL at the downstream end of their exempted reach. WLAs are presented in Table 5-9.

Table 5-9. Segment IL_NH-06 Permitted Dischargers and WLAs

NPDES ID	Facility Name	Disinfection exemption?	Design average flow (MGD)	WLA (cfu/day)
ILG580221	HANAFORD STP	Yes, year-round	0.042	3.18E+08
IL0061760	HILL CITY APARTMENTS-BENTON	Yes, year-round	0.004	3.03E+07
IL0065111	REND LAKE CONS. DIST. STP	Yes, year-round	0.5	3.79E+09

The total WLA for the three (3) point source dischargers in the IL_NH-06 watershed is 4.13E+09 cfu/day.

The remainder of the loading capacity is given to the load allocation for nonpoint sources as an implicit MOS was used in this TMDL (Table 5-10). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall fecal coliform load.

Table 5-10. Fecal Coliform TMDL for Segment IL_NH-06 Upper Big Muddy River[1]

Upper Big Muddy River Flow (cfs)	Allowable Load (cfu/day)	Wasteload Allocation (WLA) (cfu/day)	Load Allocation (LA) (cfu/day)
6.5	3.17E+10	4.13E+09	2.75E+10
8.1	3.99E+10	4.13E+09	3.57E+10
11.3	5.52E+10	4.13E+09	5.10E+10
18.0	8.79E+10	4.13E+09	8.38E+10
29.2	1.43E+11	4.13E+09	1.39E+11
48.0	2.35E+11	4.13E+09	2.31E+11
79.4	3.88E+11	4.13E+09	3.84E+11
134	6.54E+11	4.13E+09	6.50E+11
313	1.53E+12	4.13E+09	1.53E+12
3716	1.82E+13	4.13E+09	1.82E+13

[1]This TMDL has an implicit Margin of Safety, so MOS is not included in this table.

5.4.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figure 4-9 provides a graphical depiction of the data compared to the load capacity, showing that exceedances of the TMDL target occur over the full range of flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions; therefore critical conditions were addressed during TMDL development.

5.4.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The load capacity calculation approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in any given point in the season where the standard applies.

5.4.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The fecal coliform TMDL contains an implicit margin of safety, through the use of multiple conservative assumptions. First, the TMDL target (no more than 200 cfu/100 mL at any point in time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 mL for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. This margin of safety can be reviewed in the future as new data are developed.

5.5 Andy Creek (IL_NZN-13) Iron TMDL

A load capacity calculation approach was applied to support development of dissolved iron TMDL for Andy Creek segment IL_NZN-13.

5.5.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity was defined over a range of specified flows based on expected flows. The allowable loading capacity was computed by multiplying the estimated flow in Andy Creek by the TMDL target concentration of 1 mg/l (Table 5-11).

Table 5-11. Iron Load Capacity (IL_NZN-13)

Flow Exceedance Percentile from the LDC	Stream Flow (cfs)	Allowable Load (lbs/day)
90%	0.1	0.27
80%	0.2	1.0
70%	0	2.5
60%	1	5.5
50%	2	1.3
40%	5	2.6
30%	9	4.8
20%	15	8.3
10%	40	2.1
5%	99	5.4

The maximum dissolved iron concentrations were examined for each flow duration interval, as shown in Table 5-12, in order to estimate the percent reduction in existing loads required to meet the 1 mg/l target. Reductions of up to 9.9% in current loads are needed at higher river flows to meet the target. No reductions are needed at lower flows.

Table 5-12. Required Reductions in Existing Loads under Different Flow Conditions (IL_NZN-13)

Flow Percentile Interval	Stream Flow (cfs)	# samples > 1 mg/L / # samples	Maximum Dissolved Iron concentration (mg/L)	Percent Reduction to Meet Target
0 - 30	3,572 - 9	1 / 1	1.11	9.9%
30 - 70	9 - 0.46	0 / 1	0.081	-
70 - 100	0.46 - 0	0 / 1	0.038	-

5.5.2 Allocation

A TMDL consists of a waste load allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

There are no permitted dischargers of iron in the Andy Creek segment IL_NZN-13 watershed, and therefore the wasteload allocation did not need to be calculated.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and the MOS (Table 5-13). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall iron load.

Table 5-13. Iron TMDL for Andy Creek (Segment IL_NZN-13)

Stream Flow (cfs)	Allowable Load (lbs/day)	MOS (10%) (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load Allocation (LA) (lbs/day)
0.05	0.27	0.03	0	0.24
0.19	1.04	0.10	0	0.94
0.46	2.46	0.25	0	2.2
1.0	5.54	0.55	0	5.0
2.4	13.2	1.3	0	11.9
4.8	26.0	2.6	0	23.4
9.0	48.5	4.9	0	43.7
15	83.1	8.3	0	74.8
40	215	22	0	194
472	2541	254	0	2287

5.5.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figure 4-6 provides a graphical depiction of the data compared to the load capacity, showing that the TMDL target is exceeded during higher flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions, including high flows; therefore critical conditions were addressed during TMDL development.

5.5.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The iron standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the stream.

5.5.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The iron TMDL contains an explicit margin of safety of 10%. This 10% margin of safety was included to address potential uncertainty in the effectiveness of load reduction alternatives. This margin of safety can be reviewed in the future as new data are developed.

5.6 Beaver Creek (IL_NGAZ-JC-D1) Manganese TMDL

A load capacity calculation approach was applied to support development of an atrazine TMDL for Beaver Creek segment IL_NGAZ-JC-D1.

5.6.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity was defined over a range of specified flows based on expected flows. The allowable loading capacity was computed by multiplying the estimated Beaver Creek flow by the TMDL target concentration of 4.85 mg/l (Table 5-14).

Table 5-14. Manganese Load Capacity (IL_NGAZ-JC-D1)

Flow Exceedance Percentile from the LDC	Beaver Creek Flow (cfs)	Allowable Load (lbs/day)
80%	0.006	0.15
70%	0.01	0.36
60%	0.03	0.81
50%	0.07	1.93
40%	0.15	3.80
30%	0.27	7.10
20%	0.47	12.16
10%	1.2	31.42
5%	3.0	78.36
1%	14	371.98

The maximum manganese concentrations were examined for each flow duration interval, as shown in Table 5-15, in order to estimate the percent reduction in existing loads required to meet the 4.85 mg/L target. Reductions of 24.4% of current loads are needed based on the single water quality sample data point sampled in the normally occurring flows interval. No reductions are are able to be calculated at lower or higher flows based on the data available.

Table 5-15. Required Reductions in Existing Loads under Different Flow Conditions (IL_NGAZ-JC-D1)

Flow Percentile Interval	Beaver Creek Flow (cfs)	# samples > 4.85 mg/l samples	Maximum Manganese concentration (mg/L)	Percent Reduction to Meet Target
0 - 30	108 - 0.27	0 / 0	-	-
30 - 70	0.27 - 0.01	1 / 1	6.41	24.4%
70 - 100	0.01 - 0	0 / 0	-	-

5.6.2 Allocation

A TMDL consists of a waste load allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

There are no permitted dischargers of manganese in the Beaver Creer segment IL_NGAZ-JC-D1 watershed, and therefore the wasteload allocation did not need to be calculated.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and the MOS (Table 5-16). The load allocations are not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall manganese load.

Table 5-16. Manganese TMDL for Beaver Creek (Segment IL_NGAZ-JC-D1)

Flow (cfs)	Allowable Load (lbs/day)	MOS (10%) (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load Allocation (LA) (lbs/day)
0.01	0.36	0.04	0	0.32
0.03	0.81	0.08	0	0.73
0.07	1.9	0.2	0	1.7
0.15	3.8	0.4	0	3.4
0.27	7.1	0.7	0	6.4
0.5	12.2	1.2	0	11.0
1.2	31.3	3.1	0	28.2

5.6.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figure 4-8 provides a graphical depiction of the data compared to the load capacity, showing that the TMDL target is exceeded during higher flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions, including high flows; therefore critical conditions were addressed during TMDL development.

5.6.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The atrazine standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the river.

5.6.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The manganese TMDL contains an explicit margin of safety of 10%. This 10% margin of safety was included to address potential uncertainty in the effectiveness of load reduction alternatives. This margin of safety can be reviewed in the future as new data are developed.

5.7 Herrin Old (IL_RNZD) Total Phosphorus TMDL

5.7.1 Calculation of the Loading Capacity

The loading capacity for Herrin Old Reservoir was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations and/or internal phosphorus loadings for each simulation until model results demonstrated attainment of the water quality objective.

The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

The initial BATHTUB simulations and the sampling data from 2013 indicated that Herrin Old Reservoir phosphorus concentrations would meet the the water quality standards using the lake-averaged phosphorus concentrations. The sampling data indicated that the only exceedances of the water quality standard were at the deepest parts of the lake, which indicates that the internal phosphorus source needs to be reduced by either capping the sediments (e.g. alum treatment or similar), or by dredging any organic sediments from the lake. The resulting load, with calibrated tributary concentrations and no additional sediment phosphorus load yields an average phosphorus load of 0.23 kg/day (0.51 lbs/day) and a concentration of 0.029 mg/L. This is below the phosphorus target of 0.05 mg/L, so reductions in the tributary loads are not necessary.

5.7.2 Allocation

A TMDL consists of a waste load allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

There are no point sources in the watershed, and therefore there is no wasteload allocation given for Herrin Old Reservoir. The entire loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The loading capacity is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 0.23 kg/day (0.51 lbs/day), and an explicit margin of safety of 10% (discussed below), the load allocation for Herrin Old Reservoir of 0.21 kg/day (0.46 lbs/day).

5.7.3 Critical Conditions

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. In terms of loading, spring runoff periods are considered critical because wet weather events can transport significant quantities of nonpoint source loads to lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. This TMDL is based upon an annual period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

5.7.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for this TMDL is designed to evaluate loads over a seasonal to annual averaging period. The annual loading analysis that was used is appropriate due to the facts that:

1. The analysis demonstrated that the TMDL could only attain water quality targets if a significant reduction was achieved in sediment phosphorus release.
2. There is a long response time between phosphorus loading and sediment response, typically on the order of several years (e.g. Chapra and Canale, 1991).

5.7.5 Margin of Safety

The TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit total phosphorus load allocated to the margin of safety is 0.02 kg/day (0.04 lbs/day) for Herrin Old Reservoir.

5.7.6 Reserve Capacity

This watershed is located in Williamson County, the population of which has increased by 8.3% between 2000 and 2010 (Stage 1 Report Section 2.6). In 2010, the U.S. Census Bureau estimated the Franklin County population at 66,357.

The Illinois Department of Public Health population projections (Shahidullah 2015) for Williamson County shows a slight population increase to 69,246 in the year 2025. Further, the Greater Egypt Regional Planning and Development Commission, referencing US Census Bureau projections, states that the population in the Greater Egypt 5-county area which includes Williamson County will be relatively steady (or slightly declining) through 2030 (GERPDC 2010).

A reserve capacity is not needed, due to the slight projected increase in population, and because, at this time IEPA is not aware of any increases in discharges from the existing point sources, or the establishment of future municipal or industrial point sources.

5.7.7 TMDL Summary

The total phosphorus TMDL for Herrin Old Reservoir, segment IL_RNZD, is presented in Table 5-17.

Table 5-17. Herrin Old Reservior IL_RNZD TMDL Summary

Allocation	Total Phosphorus Load kg/day (lbs/day)
Load Capacity (LC)	0.23 (0.51)
Wasteload Allocation (WLA)	Not applicable. There are no permitted dischargers in this watershed
Load Allocation (LA)	0.21 (0.46)
Margin of safety (10% of LC)	0.02 (0.05)

5.8 Johnston City (IL_RNZE) Total Phosphorus TMDL

5.8.1 Calculation of the Loading Capacity

The loading capacity for Johnston City Reservoir was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment of the water quality objective. The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Initial BATHTUB load reduction simulations indicated that Johnston City Reservoir phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, or in response to management actions to remove organic sediments from the lake, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional internal sediment phosphorus source for future scenarios. The resulting load, with calibrated tributary concentrations and no additional sediment phosphorus load yields an average phosphorus load of 0.43 kg/day (0.95 lbs/day) and a concentration of 0.048 mg/L. This meets the phosphorus target of 0.05 mg/L, so reductions in the tributary loads are not necessary. Therefore, the loading capacity is equal to the current incoming loads of 0.43 kg/day (0.95 lbs/day).

5.8.2 Allocation

A TMDL consists of a waste load allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

There are no point sources in the watershed, and therefore there is no wasteload allocation given for Johnston City Reservoir. The entire loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The loading capacity is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 0.2 kg/day (0.44 lbs/day), and an explicit margin of safety of 10% (discussed below), the load allocation for Johnston City Reservoir of 0.18 kg/day (0.40 lbs/day).

5.8.3 Critical Conditions

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. In terms of loading, spring runoff periods are considered critical because wet weather events can transport significant quantities of nonpoint source loads to lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. This TMDL is based upon an annual period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

5.8.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for this TMDL is designed to evaluate loads over a seasonal to annual averaging period. The annual loading analysis that was used is appropriate due to the facts that:

1. The analysis demonstrated that the TMDL could only attain water quality targets if a significant reduction was achieved in sediment phosphorus release.
2. There is a long response time between phosphorus loading and sediment response, typically on the order of several years (e.g. Chapra and Canale, 1991).

5.8.5 Margin of Safety

The TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit total phosphorus load allocated to the margin of safety is 0.02 kg/day (0.04 lbs/day) for Johnston City Lake.

5.8.6 Reserve Capacity

This watershed is located in Williamson County, the population of which has increased by 8.3% between 2000 and 2010 (Stage 1 Report Section 2.6). In 2010, the U.S. Census Bureau estimated the Franklin County population at 66,357.

The Illinois Department of Public Health population projections (Shahidullah 2015) for Williamson County shows a slight population increase to 69,246 in the year 2025. Further, the Greater Egypt Regional Planning and Development Commission, referencing US Census Bureau projections, states that the population in the Greater Egypt 5-county area which includes Williamson County will be relatively steady (or slightly declining) through 2030 (GERPDC 2010).

A reserve capacity is not needed, due to the slight projected increase in population, and because, at this time IEPA is not aware of any increases in discharges from the existing point sources, or the establishment of future municipal or industrial point sources.

5.8.7 TMDL Summary

The total phosphorus TMDL for Johnston City Lake, segment IL_RNZE, is presented in Table 5-18.

Table 5-18. Johnston City Lake IL_RNZE TMDL Summary

Allocation	Total Phosphorus Load kg/day (lbs/day)
Load Capacity (LC)	0.48 (1.06)
Wasteload Allocation (WLA)	Not applicable. There are no permitted dischargers in this watershed
Load Allocation (LA)	0.43 (0.95)
Margin of safety (10% of LC)	0.05 (0.11)

5.9 Arrowhead (Williamson) (IL_RNZX) Total Phosphorus TMDL

5.9.1 Calculation of the Loading Capacity

The loading capacity for the Arrowhead (Williamson) Reservoir was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment of the water quality objective. The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Initial BATHTUB load reduction simulations indicated that Arrowhead (Williamson) Reservoir phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions and/or potential management actions (e.g. dredging organic sediments, alum treatment), reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional internal sediment phosphorus source for future scenarios. The resulting load, with calibrated tributary concentrations and no additional sediment phosphorus load yields an average phosphorus load of 0.11 kg/day (0.24 lbs/day) and a lake-wide average concentration of 0.049 mg/L. The predicted lake concentrations in the upstream model segments (Segment 2 and Segment 3) are 0.05 and 0.06 mg/l respectively. Therefore reductions in the tributary loads are necessary to meets the phosphorus target of 0.05 mg/L across the entire waterbody. The loading capacity was an average of 0.085 kg/day (0.19 lbs/day). This allowable load corresponds to an approximately 30% reduction from existing tributary loads.

5.9.2 Allocation

A TMDL consists of a waste load allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

There are no point sources in the watershed, and therefore there is no wasteload allocation given for Arrowhead (Williamson) Reservoir. The entire loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The loading capacity is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 0.085 kg/day (0.19 lbs/day), and an explicit margin of safety of 10% (discussed below), the load allocation for Arrowhead (Williamson) Reservoir of 0.076 kg/day (0.17 lbs/day).

5.9.3 Critical Conditions

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. In terms of loading, spring runoff periods are considered critical because wet weather events can transport significant quantities of nonpoint source loads to lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. This TMDL is based upon an annual period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

5.9.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for this TMDL is designed to evaluate loads over a seasonal to annual averaging period. The annual loading analysis that was used is appropriate due to the facts that:

3. The analysis demonstrated that the TMDL could only attain water quality targets if a significant reduction was achieved in sediment phosphorus release.
4. There is a long response time between phosphorus loading and sediment response, typically on the order of several years (e.g. Chapra and Canale, 1991).

5.9.5 Margin of Safety

The TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit total phosphorus load allocated to the margin of safety is 0.008 kg/day (0.02 lbs/day) for Arrowhead (Williamson) Reservoir.

5.9.6 Reserve Capacity

The Arrowhead (Williamson) Reservoir watershed is located in Williamson County, the population of which has increased by 8.3% between 2000 and 2010 (Stage 1 Report Section 2.6). In 2010, the U.S. Census Bureau estimated the Franklin County population at 66,357.

The Illinois Department of Public Health population projections (Shahidullah 2015) for Williamson County shows a slight population increase to 69,246 in the year 2025. Further, the Greater Egypt Regional Planning and Development Commission, referencing US Census Bureau projections, states that the population in the Greater Egypt 5-county area which includes Williamson County will be relatively steady (or slightly declining) through 2030 (GERPDC 2010).

A reserve capacity is not needed, due to the slight projected increase in population, and because, at this time IEPA is not aware of any increases in discharges from the existing point sources, or the establishment of future municipal or industrial point sources.

5.9.7 TMDL Summary

The total phosphorus TMDL for Arrowhead (Williamson) Reservoir, segment IL_RNZX, is presented in Table 5-19.

Table 5-19. Arrowhead (Williamson) IL_RNZX TMDL Summary

Allocation	Total Phosphorus Load kg/day (lbs/day)
Load Capacity (LC)	0.085 (0.19)
Wasteload Allocation (WLA)	Not applicable. There are no permitted dischargers in this watershed
Load Allocation (LA)	0.076 (0.17)
Margin of safety (10% of LC)	0.008 (0.02)

5.10 West Frankfort Old (IL_RNP) Total Phosphorus TMDL

Calculation of the Loading Capacity

The loading capacity for West Frankfort Old Reservoir was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment of the water quality objective. The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Initial BATHTUB load reduction simulations indicated that West Frankfort Old Reservoir phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional internal sediment phosphorus source for future scenarios. The resulting load, with calibrated tributary concentrations and no additional sediment phosphorus load yields an average phosphorus load of 1.99 kg/day (4.37 lbs/day) and a concentration of 0.11 mg/L. This exceeds the phosphorus target of 0.05 mg/L, so reductions in the tributary loads are necessary. The loading capacity was an average of 0.50 kg/day (1.09 lbs/day). This allowable load corresponds to an approximately 75% reduction from existing tributary loads.

5.10.1 Allocation

A TMDL consists of a waste load allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

There are no point sources in the watershed, and therefore there is no wasteload allocation given for West Frankfort Old Reservoir. The entire loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The loading capacity is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 0.50 kg/day (1.09 lbs/day), and an explicit margin of safety of 10% (discussed below), the load allocation for West Frankfort Old Reservoir of 0.45 kg/day (0.98 lbs/day).

5.10.2 Critical Conditions

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. In terms of loading, spring runoff periods are considered critical because wet weather events can transport significant quantities of nonpoint source loads to lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. This TMDL is based upon an annual period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

5.10.3 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for this TMDL is designed to evaluate loads over a seasonal to annual averaging period. The annual loading analysis that was used is appropriate due to the facts that:

1. The analysis demonstrated that the TMDL could only attain water quality targets if a significant reduction was achieved in sediment phosphorus release.
2. There is a long response time between phosphorus loading and sediment response, typically on the order of several years (e.g. Chapra and Canale, 1991).

5.10.4 Margin of Safety

The TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit total phosphorus load allocated to the margin of safety is 0.05 kg/day (0.11 lbs/day) for West Frankfort Old Reservoir.

5.10.5 Reserve Capacity

The West Frankfort Old Reservoir watershed is located in Franklin County, the population of which has increased by 1.4% between 2000 and 2010 (Stage 1 Report Section 2.6). In 2010, the U.S. Census Bureau estimated the Franklin County population at 39,570.

The Illinois Department of Public Health population projections (Shahidullah 2015) for Franklin County shows a slight population decline to 37,958 in the year 2025. Further, the Greater Egypt Regional Planning and Development Commission, referencing US Census Bureau projections, states that the population in the Greater Egypt 5-county area which includes Franklin County will be relatively steady (or slightly declining) through 2030 (GERPDC 2010).

A reserve capacity is not needed, due to the slight projected decrease in population, and because, at this time IEPA is not aware of any increases in discharges from the existing point sources, or the establishment of future municipal or industrial point sources.

5.10.6 TMDL Summary

The total phosphorus TMDL for West Frankfort Old Reservoir, segment IL_RNP, is presented in Table 5-20.

Table 5-20. West Frankfort Old IL_RNP TMDL Summary

Allocation	Total Phosphorus Load kg/day (lbs/day)
Load Capacity (LC)	0.50 (1.09)
Wasteload Allocation (WLA)	Not applicable. There are no permitted dischargers in this watershed
Load Allocation (LA)	0.45 (0.98)
Margin of safety (10% of LC)	0.05 (0.11)

5.11 West Frankfort New (IL_RNQ) Total Phosphorus TMDL

5.11.1 Calculation of the Loading Capacity

The loading capacity for West Frankfort New Reservoir was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment of the water quality objective. The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Initial BATHTUB load reduction simulations indicated that West Frankfort New Reservoir phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions or lake management actions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional internal sediment phosphorus source for future scenarios. The resulting load, with calibrated tributary and Thompsonville STP concentrations and no additional sediment phosphorus load yields an average phosphorus load of 3.63 kg/day (7.99 lbs/day) and a concentration of 0.104 mg/L. This exceeds the phosphorus target of 0.05 mg/L, so reductions in the tributary loads are necessary. The loading capacity calculated was an average of 0.91 kg/day (2.0 lbs/day). This allowable load corresponds to an approximately 75% reduction from existing loads, estimated as 3.68 kg/day (8.11 lbs/day).

5.11.2 Allocation

A TMDL consists of a waste load allocation (WLA) for point sources, a load allocation (LA) for nonpoint sources and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

There is a single point sources in the watershed from the Thompsonville STP (IL0072478). The current treatment at this facility consists of two cell aerated lagoon and a rock filter. These treatment processes are not capable of removing significant amount of total phosphorus from the effluent. The design average flow (DAF) for the facility is 0.08 million gallons per day (MGD) and the design maximum flow (DMF) for the facility is 0.20 MGD.

The average daily flows from this STP reported in the DMRs from 2008 through 2016 0.087 MGD. There is no water quality data for total phosphorus from this point source to use for model calibration. In estimating the existing phosphorus load from this facility, a total phosphorus concentration in the STP effluent was assumed to be 3.66 mg/L. The resulting average load from the Thompsonville STP is 1.20 kg/day (2.64 lb/day). This load along is higher than the loading capacity of the reservoir, so reductions will be necessary to meet the water quality standards. The WLA for this facility was developed based on the DAF, and a target effluent concentration of 1.0 mg/L. This results in an average WLA of 0.30 kg/day (0.67 lb/day), which represents a 74.6% reduction from the estimated current load.

The remaining loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The load allocation for nonpoint sources is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a total loading capacity of 0.91 kg/day (2.0 lbs/day), a WLA for the Thompsonville STP of 0.30 kg/day (0.72 lb/day), and an explicit margin of safety of 10% (discussed below), the load allocation for West Frankfort New Reservoir is 0.52 kg/day (1.15 lbs/day). This represents a reduction of approximately 79% of the watershed nonpoint sources from the existing loads.

5.11.3 Critical Conditions

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. In terms of loading, spring runoff periods are considered critical because wet weather events can transport significant quantities of nonpoint source loads to lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. This TMDL is based upon an annual period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

5.11.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for this TMDL is designed to evaluate loads over a seasonal to annual averaging period. The annual loading analysis that was used is appropriate due to the facts that:

1. The analysis demonstrated that the TMDL could only attain water quality targets if a significant reduction was achieved in sediment phosphorus release.
2. There is a long response time between phosphorus loading and sediment response, typically on the order of several years (e.g. Chapra and Canale, 1991).

5.11.5 Margin of Safety

The TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit total phosphorus load allocated to the margin of safety is 0.09 kg/day (0.2 lbs/day) for West Frankfort New Reservoir.

5.11.6 Reserve Capacity

This watershed is located in Franklin County, the population of which has increased by 1.4% between 2000 and 2010 (Stage 1 Report Section 2.6). In 2010, the U.S. Census Bureau estimated the Franklin County population at 39,570.

The Illinois Department of Public Health population projections (Shahidullah 2015) for Franklin County shows a slight population decline to 37,958 in the year 2025. Further, the Greater Egypt Regional Planning and Development Commission, referencing US Census Bureau projections, states that the population in the Greater Egypt 5-county area which includes Franklin County will be relatively steady (or slightly declining) through 2030 (GERPDC 2010).

A reserve capacity is not needed, due to the slight projected decrease in population, and because, at this time IEPA is not aware of any increases in discharges from the existing point sources, or the establishment of future municipal or industrial point sources.

5.11.7 TMDL Summary

The total phosphorus TMDL for West Frankfort New Reservoir, segment IL_RNQ, is presented in Table 5-21.

Table 5-21. West Frankfort New Reservoir IL_RNQ TMDL Summary

Allocation	Total Phosphorus Load kg/day (lbs/day)
Load Capacity (LC)	0.91 (2.01)
Wasteload Allocation (WLA)	0.30 (0.67)
Load Allocation (LA)	0.52 (1.15)
Margin of safety (10% of LC)	0.09 (0.20)

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6
LRS Development

This section presents the development of the total suspended solids Load Reduction Strategy for 5 streams in the Upper Big Muddy River watershed. IEPA requires a LRS to identify the load capacity, and the percentage reduction needed.

6.1 TSS Load Reduction Strategy - Streams

The load capacity was calculated by multiplying the total suspended solids concentration of 32.2 mg/L by the average annual 2015 Upper Big Muddy River flows estimated using a drainage area ratio approach and USGS measured flows for Upper Big Muddy River at Browns, IL (Gage 03378000). The percent reduction was calculated by comparing the average TSS concentrations for the monitoring stations located on the segment calculated from the full record of measured total suspended solids concentrations (Attachment 1 and Attachment 2) to the LRS target concentration.

Table 6-1 presents the TSS LRSs for all of the waterbodies in the Upper Big Muddy River watershed.

Table 6-1. Total Suspended Solids LRS

Stream (Segment ID)	Monitoring Station(s)	Target (mg/L)	Average Concentration (mg/L)	Current load (lbs/day)	Load capacity (lbs/day)	Percent Reduction
Big Muddy R. (IL_N-06)	N-06	32.2	43.7	16,148	11,910	26.2%
Big Muddy R. (IL_N-11)	N-11	32.2	53.0	31,932	19,395	39.3%
Big Muddy R. (IL_N-17)	N-17	32.2	110.3	27,108	7,911	70.8%
Pond Cr. (IL_NG-02)	NG-02	32.2	86.3	39,449	14,721	62.7%
M. Fk. Big Muddy (IL_NH-07)	NH-07, NH-08, NH-21	32.2	72.3	53,894	23,992	55.5%

7 Reasonable Assurances

Documenting adequate reasonable assurance increases the probability that regulatory and voluntary mechanisms will achieve pollution reduction levels specified in the TMDL and that the applicable WQS are attained.

The Illinois EPA NPDES regulatory program and the issuance of an NPDES permit provide the reasonable assurance that the WLAs in the TMDL will be achieved. That is because federal regulations implementing the CWA require that effluent limits in permits be consistent with "the assumptions and requirements of any available [WLA]" in an approved TMDL [40 CFR 122.44(d)(1)(vii)(B)]. For point sources, Illinois EPA administers the NPDES permitting program for wastewater treatment plants, MS4s and CAFOs. Wasteload allocations in the TMDL report will be included in the appropriate NPDES permits when permits are renewed.

For TMDLs for waters impaired by both point and nonpoint sources, determinations of reasonable assurance that the TMDLs load allocations will be achieved include whether practices capable of reducing the specified pollutant load exist, are technically feasible, and have a high likelihood of implementation. The nonpoint source load reductions can and will be achieved when there are good management practices and programs (technical and funding mechanisms) to assist in achieving good management practices. The Watershed Implementation Plan for the TMDLs contained in this report identifies practices that are capable of reducing the pollutant loads to the TMDL endpoints, and potential funding mechanisms for implementation.

For nonpoint sources, the primary strategy for reduction for attaining water quality standards in the Upper Big Muddy River watershed is to implement BMPs to reduce and treat agricultural and urban stormwater runoff, along with the use of in-stream restoration practices. This strategy relies on voluntary actions that includes accountability. Educational efforts and cost sharing programs are intended to achieve participation levels sufficient to attain water quality standards and meet the designated uses. An important key to the success of a TMDL program, in terms of engaging the public, is building linkages to other programs, such as nonpoint source management practices.

In rural areas many homes, businesses, and schools do not have access to central sewage disposal systems. County and local health departments operate sewage and water programs to assure that sewage and water systems are designed according to code so that neither the public health nor the environment is jeopardized. The counties and local health departments issue licenses and provide training to contractors, inspect and license pumper trucks, review sewage system applications, issue construction permits, assist in the design of sewage disposal systems, inspect new sewage disposal systems, investigate complaints, and carry out enforcement activities based upon county ordinances. These activities help to eliminate the discharge of raw sewage and reduce the bacterial contamination within the Upper Big Muddy River watershed.

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8
Public Participation and Involvement

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Attachment 1:
Stage 1 Report

Attachment 2. 2015 IEPA Stage 2 Monitoring Data
2015 Upper Big Muddy River Watershed Data

Attachment 3:

QUAL2E Model Files

Calibration input

Calibration output

Attachment 4: BATHTUB Model Files

Herrin Old / IL_RNZD
Calibration input
Calibration output
Johnston City / IL_RNZE
Calibration input
Calibration output
Arrowhead (Williamson) / IL_RNZX
Calibration input
Calibration output
West Frankfort Old / IL_RNP
Calibration input
Calibration output
West Frankfort New/ IL_RNQ
Calibration input
Calibration output

Attachment 5: Load Duration Curve Analysis

IL_N-11 Fecal Coliform LDC

IL_NZN-13 Iron LDC

IL_NG-02 Chloride LDC

IL_NGAZ-JC-D1 Manganese LDC

IL_NH-06 Fecal Coliform LDC